UNCLASSIFIED

N-63-4-3

FORECASTING TRAFFICABILITY OF SOILS

AIRPHOTO APPROACH

TECHNICAL MEMORANDUM NO. 3-331

Report 6

Volume II

June 1963

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

FORECASTING TRAFFICABILITY OF SOILS

AIRPHOTO APPROACH

TECHNICAL MEMORANDUM NO. 3-331

Report 6

Volume II

June 1963

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

Table 1

Unified Soil Classification System

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)			Information Required for Describing Soils
1	2		3	4	5			6
Coarse-grained Soils More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixture.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			
	Sands More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.			
			SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size			
					Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	
Fine-grained Soils More than half of material is smaller than No. 200 sieve size.	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses.
	Silts and Clays Liquid limit is greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML).
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classif screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toug

Af

Af

Th

Hi

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952.

2

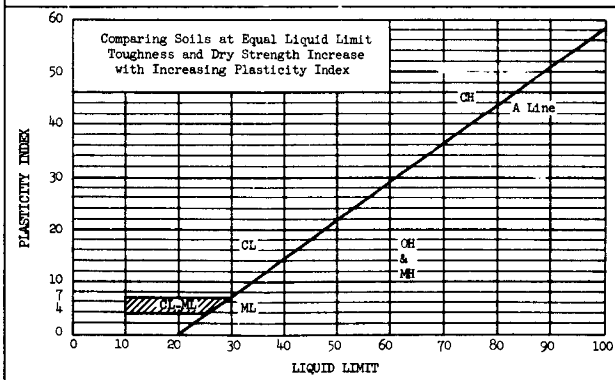
Table 1

Unified Soil Classification System

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Information Required for Describing Soils			Laboratory Classification Criteria	
	5	6			7	
...tures,	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics.	Use grain-size curve in identifying the fractions as given under field identification.	Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% = GW, GP, SW, SP. More than 12% = GM, GC, SM, SC. 5% to 12% = Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
... mixtures,	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for GW	
...ure.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).	Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.			Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
...tures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7	
...ittle or	Wide range in grain size and substantial amounts of all intermediate particle sizes.				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
...s, little	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for SW	
	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).	Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).			Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7	

	Identification Procedures on Fraction Smaller than No. 40 Sieve Size				
	Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)		
... rock ... or ...y.	None to slight	Quick to slow	None	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.	Use grain-size curve in identifying the fractions as given under field identification.
...asticity, ... clays,	Medium to high	None to very slow	Medium		
...s of low	Slight to medium	Slow	Slight	Give typical name; indic degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	
...aceous ... silts.	Slight to medium	Slow to none	Slight to medium		
... fat clays.	High to very high	None	High		
...ticity,	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML).	
	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				



PLASTICITY CHART

For laboratory classification of fine-grained soils

...are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

...es are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

...t ...ssary ...sts ...very ... and ...e ...ur,

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

021260A

Table 2

Frequency of USDA Soil Types Occurring as USCS Soil Types

USDA Soil Type			USCS Soil Type: Coarse-Grained Soils with Fines						Fine-Grained Soils					Organic Soils			Total
			GM	GC	SP-SM	SM	SM-SC	SC	ML	CL-ML	MH	CL	CH	OL	OH	Pt	% / n
Sandy Soils	S	%			47	50	3										100
		n			21	22	1										44
	LS	%				98		2									100
		n				56		1									57
	SL†	%	*			41	8	14	19	4		9		2	2		100
		n	1			85	17	28	40	9		18		5	4		207
	SCL	%				11	3	25	7			54					100
		n				3	1	7	2			15					28
	SC	%						50				50					100
		n						1				1					2
Clayey, Silty, and Loamy Soils	L†	%	*	*					22	11	*	52	3	3	6		100
		n	1	1					36	19	1	87	5	5	10		165
	SiL	%							36	10	3	45	2	2	2		100
		n							172	47	16	215	12	9	10		481
	Si	%							91			9					100
		n							10			1					11
	CL	%							5		3	75	15		2		100
		n							2		1	30	6		1		40
	SiCL	%							1	1	1	67	27		3		100
		n							1	1	1	51	20		2		76
	SiC	%							5			24	71				100
		n							1			5	15				21
	C	%							3		10	13	66		8		100
		n							1		4	5	25		3		38
Organic Soil	Pt	%														100	100
		n														6	6
Total samples																	1176

n Number of samples.
* Less than 1%.
† Prefixed with the term gravelly, cobbly, or stony for GM or GC soil types.

Sample Interpretation

	CL	
SiL	45	
		215

45% of all SiL samples were CL. The circle indicates that a greater number of SiL samples occurred as CL than as any other USCS type. 215 samples were classified as SiL and CL.

Table 3

Trafficability Characteristics of USCS Soils in Wet Season

Class	Soils	USCS Soil Type	Probable CI Range	Probable RI Range	Probable RCI Range	Slipperiness Effects	Stickiness Effects	Comments
A	Coarse-grained, cohesionless sand and gravels	GW, GP, SW, SP	80 to 300	1	80 to 300	Slight to none	None	Will support continuous traffic of military vehicles with tracks or with high-flotation tires. Moist sands are good, dry sand only fair. Wheeled vehicles with standard tires may be immobilized in dry sands
B	Inorganic clays of high plasticity, fat clays	CH	55 to 165	0.75 to 1.35	65 to 140	Severe to slight	Severe to slight	Usually will support more than 50 passes of military vehicles. Going will be difficult at times
C	Clayey gravels, gravel-sand-clay mixtures	GC	85 to 175	0.45 to 0.75	45 to 125	Severe to slight	Moderate to slight	Often will not support 40 to 50 passes of military vehicles, but usually will support limited traffic. Going will be difficult in most cases
	Clayey sand, sand-clay mixtures	SC						
	Gravelly clays, sandy clays, inorganic clays of low to medium plasticity, lean clays, silty clays	CL						
D	Silty gravels, gravel-sand-silt mixtures	GM	85 to 180	0.25 to 0.85	25 to 120	Moderate to slight	Slight	Usually will not support 40 to 50 passes of military vehicles. Often will not permit even a single pass. Going will be difficult in most cases
	Silty sands, sand-silt mixtures	SM						
	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	ML and CL-ML						
	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH						
	Organic silts and organic silty clays of low plasticity	OL						
	Organic clays of medium to high plasticity, organic silts	OH						
E	Peats and mucks	Pt	10 to 100	0.25 to 0.65	10 to 85	Slight to none	Moderate to slight	Often will not permit even a single pass. Going will be difficult to impossible

Note: Taken from Trafficability of Soils, A Summary of Trafficability Studies Through 1955, TM No. 3-240, 14th Supplement, December 1956.

Table 4

Classification and Implications of Drainage Patterns

Classification	Definitions and Diagnostic Features	Parent Materials and Other Implications
I. Collection systems	Systems which drain surface water away from a region	
A. Fundamental patterns		
1. Integrated	Natural lakes, swamps, or marshes rare or absent	
a. Dendritic	Channel directions random, but regional drainage direction consistent	Flat-lying and weakly jointed stratified rocks, nonstratified rocks, and thick unconsolidated material without pronounced regional dip
b. Rectangular	Channels subparallel in two directions at roughly right angles; channels outline roughly rectangular uplands	Strongly jointed or faulted rocks; may be either nonstratified or flat-lying stratified
c. Trellis	Channels subparallel in two directions at roughly right angles; channels tend to outline elongate rectangular uplands; trunk channels strongly prefer one direction	Inclined stratified rocks; trunk channels follow weak beds, low-order tributaries drain sides of resistant ridges
d. Pinnate	Channels subparallel but low-order tributaries join trunks at angles of less than 90°	Deep, homogeneous, unconsolidated silts (loess); some flat-lying sandstones
e. Parallel	Channels subparallel with one direction of flow dominant	Gently inclined stratified rocks, or unconsolidated materials with pronounced regional slope
f. Reticular	Channels divide and coalesce in random fashion; trunk channels commonly seem too large for drainage area	Fine- to coarse-grained unconsolidated material subject to tidal inundation
2. Nonintegrated	Basins, lakes, swamps, or marshes common	
a. Swallow hole	Short, usually dendritic drainageways end abruptly in small, open holes or basins. Entire system commonly but not invariably within elongate or irregular basin	Flat-lying massive limestone
b. Glacial kettle	Short, usually dendritic or parallel drainageways end in round or irregularly shaped basins of widely variable size	Coarse-grained, unconsolidated; if basins are numerous, materials usually gravelly; if widely spaced, materials usually sandy
c. Granular subsidence	Short, usually parallel or dendritic drainageways end in broadly saucer-shaped basins	Coarse-grained, unconsolidated; usually quite thick
d. Crescentic	Usually long, more or less arcuate lakes, marshes, or swamps; usually but not invariably drained at one end by drainageway trending in same direction as axis of lake. Includes "ox-bow" lakes	Materials widely variable; fine- to coarse-grained, unconsolidated; basin commonly but not invariably floored with organic silts or clays
e. Elongated bay	Interrelated series of channels and oval lakes, swamps, or marshes. Long axes of ovals essentially parallel. Some ovals not drained by surface channels. Where surface channels exist, they usually drain all bays in one area from same end	Unconsolidated, coarse-grained material on edges; materials in bays usually very soft, unconsolidated silt, peat, or other highly organic materials
f. Deranged	Patterns in which no preferred direction of drainage is immediately evident	
(1) Random	No consistent direction or alignment; channels contorted; no consistent angle of junction; usually associated with areas of kettle drainage and dendritic drainage	Unconsolidated, widely variable, complex associations of gravel, sand, silt, and clay
(2) Aligned	Channels tend to be parallel, but direction of flow may be in either direction along alignment	Rock; may be inclined stratified or schistose with differences in erosional resistance, or nonstratified with differences in joint spacing; channels follow weaker beds of zones
(3) Thermokarst	Channels form distinctly polygonal patterns with only slight traces of integration	Widely variable unconsolidated materials; pattern indicates upset in thermal regime, commonly but not invariably in a permafrost region
g. Drainageless	No perceptible channels	
(1) Channelless basins	Elongate to irregularly shaped basins without scour channels	Coarse-grained, unconsolidated, poorly graded, low-density
(2) Channelless plains	Undulating surface without scour channels	May be either rock or gravel; if rock, usually flat-lying stratified
3. Artificial	Developed as result of modification by man	
a. Ditch	Channels form mathematically straight lines or unnaturally smooth curves; common form is abnormally regular trellis, rectangular, or parallel type; generally no control works	Usually fine-grained, unconsolidated; water table high
b. Tile	Basically similar to ditch, but drainageways defined only by differences of soil color produced by process of laying tiles, or by differences in soil moisture as result of local internal drainage	Unconsolidated, fine-grained with varying admixtures of coarse-grained materials; water table commonly high

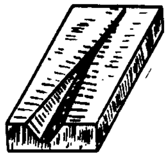
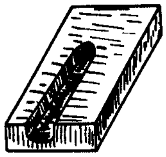
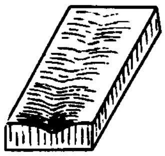
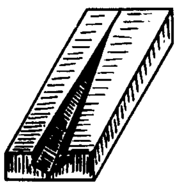
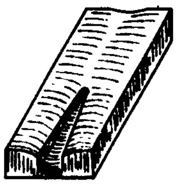
(Continued)

Table 4 (Concluded)

Classification	Definitions and Diagnostic Features	Parent Materials and Other Implications
B. Variations of fundamental patterns		
1. Centrifugal	Channels diverge from a common center; variation of parallel type	If well developed, materials commonly interbedded volcanic ash, tuff, and/or lava; if poorly developed, no parent materials implication
2. Centripetal	Channels converge toward common center	Implication dependent upon degree of development. See below
a. Subparallel	Channels relatively straight, but converge toward common center	Very regular pattern; probably volcanic crater; materials interbedded volcanic ash, tuff, other ejecta including lava Less regular patterns; if drainageways end in playa, materials usually unconsolidated, fine-grained toward center of basin, coarser toward sources of drainageways. If drainageways end in kettle or subsidence basin, materials unconsolidated and coarse-grained
b. Dendritic	Individual drainage systems dendritic, but associated valleys trend toward common center	If drainageways end in swallow hole, materials are flat-lying massive limestones; if in kettle or subsidence basin, material is coarse-grained unconsolidated
3. Collinear	Channels curved, concentric; in some places not integrated by cross-connection. Variation of parallel type	Unconsolidated, commonly coarse-grained in interfluves, but may be fine-grained along drainageways
4. Annular	Trunk channels radiate from common center, but major tributaries form concentric rings around common center. Variation of trellis, pinnate, or rectangular types	Stratified rock inclined in all directions away from (or more rarely, toward) a common center; rocks forming ridges more resistant than those forming valleys
5. Barbed	Tributary channels enter trunk channels at angles greater than 90°. Variation of dendritic, trellis, parallel, rectangular, or pinnate types	Indicative of stream piracy; materials implication must be made from character of tributaries
6. Asymmetric	Tributary channels entering opposite sides of trunk channel markedly different in type or spacing. Commonly variation of trellis, rectangular, or pinnate	Markedly different conditions on opposite sides of drainageways; commonly indicative of inclined stratified rocks, but other implications must be deduced from character of tributaries
7. Deflected	Tributary channels approaching trunk channel deflected parallel to valley walls, eventually join trunk well downstream from normal position. Variation of dendritic, rectangular, trellis, pinnate, or parallel types	Point at which deflection becomes apparent commonly marks beginning of unconsolidated materials
a. Anomalous	Tributaries enter valley of trunk stream at elevations greater than that of trunk	Materials between trunk and tributary are commonly unconsolidated, coarse-grained
b. Yazoo	Tributaries enter valley of trunk stream at elevations below that of trunk	Materials between trunk channel and tributary commonly unconsolidated, fine-grained, with admixture of sand, but other materials are not uncommon. However, materials along deflected tributary almost invariably fine-grained
8. Phantom	No distinct channels, but usually swales without scour channels connect to form integrated pattern. Usually variation of dendritic, but may also be parallel or pinnate	Unconsolidated permeable surface stratum overlying impermeable subsurface stratum
II. Distribution systems	Systems which add water to a region	
A. Fan distributary	Trunk channels break up into ever-smaller channels, each of which eventually vanishes without obvious evidence of discharge. Superficial resemblance to parallel type of collection system	Unconsolidated but widely variable; commonly coarse-grained, but silt-sized materials not uncommon. Confined almost entirely to arid or semiarid climates
B. Delta	Trunk channels break up into ever-smaller channels, all of which eventually discharge into a water body	Unconsolidated but widely variable; if trunk stream has low gradient, materials tend to be fine-grained, with minor admixtures of fine sand; if trunk stream has steep gradient, materials tend to be coarse-grained
C. Canals	Channels mathematically straight or in abnormally smooth curves; control works common	Materials generally unconsolidated, usually fine-grained with various proportions of coarse-grained materials
III. Channel types	The shape of the water surface as seen on an aerial photograph	
A. Straight	Mathematically straight or in abnormally smooth curves	Canals and other artificial waterways; usually made in unconsolidated materials, but not necessarily so
B. Sinuous	Slightly irregular curves; slight differences in width	Usually implies steep gradient and low ratio of depth to width; bed materials coarse-grained; surrounding areas usually but not invariably rock. Generally associated with folded or faulted rocks
C. Meandering	Strongly curved or looping	Usually implies low gradient and high ratio of depth to width, especially in curves, if surrounding region is an undulating surface (floodplain), materials commonly but not invariably unconsolidated and fine-grained with various admixtures of coarse-grained materials; commonly belts of relatively coarse-grained material (silty sand) along each bank. Intrenched meanders not common; in such instances, surrounding material usually either nonstratified rock, or flat-lying stratified rock
D. Braided	Channel interrupted by numerous islands	Depth-to-width ratio usually low; materials usually either coarse-grained unconsolidated, or rock

Table 5

Gully Characteristics

Symbol Used in Text	Generalized Sketch	Gradient*	Climate	Parent Materials
		Simple Types		
V		Steep	Humid	Unconsolidated: relatively homogeneous; coarse-grained; permeable; more common in noncohesive materials, but may also occur in some cohesive materials; commonly associated with rill erosion. Most common material: sand. Consolidated: virtually all materials.
			Arid	Unconsolidated: almost entirely in noncohesive materials. Consolidated: virtually all materials; sides and bottom generally very irregular.
F		Gentle	Humid	Unconsolidated: thick; relatively homogeneous; cohesive; fine-grained; permeability of soil zone fair to good, but poor in subsoil; very common in thick loess. See fig. 20. Most common material: silt. Consolidated: rare; sometimes developed along joints in limestone.
			Arid	Unconsolidated: thick; cohesive or even slightly cohesive; grain size immaterial.
		Steep	Arid	Consolidated: rare; sometimes develops in flat-lying shales; bottom commonly "stepped."
C		Gentle	Humid	Unconsolidated: fine-grained; impermeable; cohesive; permeability in both soil zone and subsoil poor; commonly associated with sheet erosion; in general, the broader the gully the more impermeable the materials. Most common materials: clay, silty clay.
		Compound Types		
FV		Steep	Humid	Unconsolidated: thin, impermeable, cohesive, fine-grained stratum overlying coarse-grained, permeable, noncohesive stratum; vertical sides may develop in coarse-grained, permeable, noncohesive material if closely bound by root mat. Consolidated: thin, cohesive strata, grain size not significant overlying rock.
CF		Gentle	Humid	Unconsolidated: very fine-grained (usually clay), cohesive, impermeable soil zone overlying fine-grained (usually silt), impermeable, cohesive stratum. Consolidated: fine-grained, impermeable, cohesive but unconsolidated surface stratum overlying rock; usually strongly angular in plan.

* The gradient of a gully or valley is the attitude of the longitudinal profile; it is the angle at which the gully or valley bottom is inclined.

Table 6

Classification of Unconsolidated Parent Materials

- Eolian materials (stratified or nonstratified)
  - Coarse-grained
    - Sand
  - Fine-grained
    - Silt (loess)
- Glacial materials (mostly nonstratified)
  - Coarse-grained
    - Gravel
    - Sand
  - Fine-grained
    - Silt
    - Clay
- Fluvial materials* (crudely stratified)
  - Coarse-grained
    - Nonorganic
      - Gravels
      - Sand
    - Organic
      - Sand
  - Fine-grained
    - Nonorganic
      - Silt
      - Clay
    - Organic
      - Silt
      - Clay
- Lacustrine materials (well stratified)
  - Coarse-grained
    - Nonorganic
      - Sand
    - Organic
      - Sand
  - Fine-grained
    - Nonorganic
      - Silt
      - Clay
    - Organic
      - Silt
      - Clay
- Littoral deposits (crudely to well stratified)
  - Coarse-grained
    - Nonorganic
      - Gravel
      - Sand
  - Fine-grained
    - Nonorganic
      - Silt
    - Organic
      - Silt
- Volcanic deposits (well stratified)
  - Coarse-grained
  - Fine-grained

* Fluvial materials, as used in this report, are many materials deposited from streams or streamlike water bodies. They thus include the so-called "glacial-fluvial" deposits, which are simply stream or flood deposits formed downgrade from an ice mass.

Table 7

Classification of Consolidated Parent Materials

Sedimentary rocks	Igneous rocks	Metamorphic rocks
Stratified*	Stratified	Stratified
Limestone	Pyroclastics	Quartzite
Dolomite	Rhyolites	Slate
Shale	Basalt	Marble
Sandstone	Nonstratified	Nonstratified
Evaporite	Granite-like	Quartzite
Nonstratified	Gabbro-like	Marble
Limestone		Gneiss
Dolomite		Schist
Shale		
Sandstone		
Evaporite		

* Stratification is used in this report in a sense applicable specifically to photo interpretation. In this context, a stratified material is one which exhibits traces of bedding within the region under examination. Thus, if the total relief of the area under examination is 150 ft, and the bedding planes of the rock are 200 ft apart, the rock may exhibit no trace of stratification in the area under examination. In this report, such rock is designated "nonstratified."

Table 8

Generalized Correlations of Landscape and Interpretive Elements
(Vegetation and Cultural Practices Not Included)

Landscape Elements			Interpretive Elements		
Drainage	Topography	Local Erosion	Parent Materials	Soil Profile	Representative Landscape
		Unconsolidated Materials			
Drainageless	Crested, rolling; many basins; uplands asymmetric; lee slope 34°	Gullies absent; blowouts, sand smears	Eolian sand	None	Dune fields, p. 59*
Regionally dendritic, locally pinnate	Rolling, blocky; relief less than 500 ft	F-type** gullies, flat grade	Eolian silt	1 to 2 ft thick; uniform, fine-grained	Loess surfaces, p. 64
Dendritic	Undulating; relief less than 40 ft	Gullies C-type, flat grade; white fringe	Glacial till; mostly fine-grained	1 to 15 ft thick; mostly fine-grained; organic in lows in some places	Old ground moraines (Illinoian stage), p. 69
Dendritic, some kettle hole and deranged	Undulating; relief less than 50 ft	Gullies C-type, flat grade	Glacial till; mostly fine-grained, heterogeneous	2 to 5 ft thick; mostly fine-grained; organic soils in lows	Young ground moraines (Wisconsin stage), p. 72
Dendritic or deranged	Rolling or crested; random; some basins; relief less than 200 ft	Gullies V-type, steep grade; saucer-shaped, flat grade	Glacial drift; heterogeneous	4 to 8 ft thick; heterogeneous	Ridge moraines, p. 75
Kettle hole or deranged; many small lakes	Rolling; basins numerous; random; relief less than 100 ft	Gullies rare; V-type, steep grade	Fluvially deposited glacial materials; coarse-grained, crudely stratified	1 to 3 ft thick; mostly coarse-grained; organic soils in kettles	Kettle-kame moraines, p. 79
Deranged; commonly ditched	Uplands rolling, parallel, drop-shaped; lowlands undulating, random	Gullies rare, C-type	Glacial drift; uplands mostly clay; lowlands fine-grained	2 to 4 ft thick; fine-grained	Drumlin fields, p. 84
Usually drainageless	Crested; conical uplands	Gullies rare; V-type, steep grade	Fluvially deposited glacial material; coarse-grained, crudely stratified	1 to 3 ft thick; mostly coarse-grained	Kames, p. 86
Usually drainageless	Crested; sinuous ridge	Gullies rare; V-type, steep grade	Fluvially deposited glacial materials; coarse-grained, crudely stratified	1 to 3 ft thick; mostly coarse-grained	Eskers, p. 86
Fan distributaries, radial parallel, parallel; channels braided	Blocky; regional slope 5° to 7°	U-shaped, V-type; saucer-shaped gullies; eolian erosion	Alluvial materials; coarse-grained near upper edge; fine-grained near lower; crudely stratified	None or very thin; desert pavement in some places; sand and gravel in washes	Alluvial fans and aprons, p. 88
Regionally crudely parallel; locally dendritic or kettle hole	Undulating; relief less than 50 ft	Gullies rare; V-type steep gradients; rare deflation basins	Fluvial materials; coarse-grained; crudely stratified	2 to 6 ft thick; coarse-grained in uplands; fine-grained and organic in lowlands	Outwash surfaces (glacial-fluvial), p. 93
Collinear, arranged in concentric areas	Undulating; relief less than 15 ft	Gullies absent	Fluvial materials; coarse-grained in uplands, fine-grained in lowlands	Thin; coarser on uplands; finer and organic on lowlands	Floodplain (ridge and swale), p. 96
Parallel or absent	Undulating or blocky; relief less than 20 ft	Gullies V-type, steep grade	Fluvial sand, silty sand	Thin; sandy silt and silty clay	Floodplain (natural levee), p. 96
Dendritic, reticulate, deranged; channels meandering, contorted, lakes common	Undulating, nearly plane	Gullies rare; C-type, flat grade	Fluvial and lacustrine silt, clay	Thin; organic, fine-grained, impermeable	Floodplain (backswamp), p. 96
Channels meandering, oxbow lakes common		Gullies absent	Fluvial and lacustrine silt, clay	Thin; organic, fine-grained, impermeable	Floodplain (abandoned course), p. 97
Dendritic, crudely collinear or parallel	Undulating, blocky; relief less than 30 ft	Gullies common; V-type, steep grade	Fluvial materials; sand, silt, clay	2 to 6 ft thick; variable; mostly fine-grained; organic	Floodplain (high-level floodplain), p. 97
Distributary; channels widely variable, resembles floodplain types	Undulating; resembles floodplain types	Gullies absent or rare	Fluvial materials; resembles floodplain types	Thickness variable; resembles floodplain types	Deltaic surfaces, p. 103
Drainageless; some swallow hole; anomalous	Undulating; small basins common; relief commonly less than 30 ft	Gullies rare; V-type, steep grade; F-type, moderate grades	Commonly coarse-grained; crudely stratified; fine-grained in some places	2 to 5 ft thick; mostly fine-grained; organic in basins	Terraces, p. 107
Dendritic, some deranged and reticulate	Undulating; relief less than 10 ft	None	Fluvial silts and clays; stratified	Thick; organic and fine-grained; impermeable	Coastal alluvial plains (coastal swamps), p. 110
Regionally crudely parallel, locally dendritic	Undulating or blocky; relief less than 50 ft	Gullies rare; F-type, moderate grade; V-type, steep grade	Gravel, sand, silty clays; crudely stratified	Thick; coarse- to fine-grained; commonly includes hardpan	Coastal alluvial plains (marine terraces), p. 111

(Continued)

* Number denotes page in Part V or Part VI on which the specific landscape is described in detail.
** For illustration of different types of gullies, see table 5.

Table 8 (Continued)

Landscape Elements			Interpretive Elements		
Drainage	Topography	Local Erosion	Parent Materials	Soil Profile	Representative Landscape
			Unconsolidated Materials (Continued)		
Dendritic	Undulating, rolling, or blocky; relief less than 100 ft	Gullies of all types common	Variable; partly to completely indurated in some places	Thick; commonly fine-grained; may include hardpan	Coastal alluvial plains (undifferentiated surfaces), p. 111
Ditched or tiled; major stream channels commonly meandering	Undulating; relief less than 10 ft	Gullies C-type, flat grade; some sheet-wash	Lacustrine materials; fine-grained, stratified	2 to 3 ft thick; fine-grained, impermeable; organic in places	Beds of perennial lakes, p. 116
Channelless	Undulating; relief less than 5 ft	Gullies absent; deflation hollows rare	Lacustrine materials; silt, clay, evaporites; stratified	Absent to thick; mostly fine-grained; evaporites in places	Playas, p. 120
Reticulate; channels meandering, contorted	Undulating; relief less than 5 ft	Ephemeral runoff channels	Littoral materials; sand, silt, silty sand	Thin or absent; organic sands or silts	Tidal flats, p. 124
Channelless basins; collinear or parallel	Undulating; sinuous ridges; relief less than 30 ft	Gullies absent; deflation hollows common	Littoral materials; coarse-grained, crudely stratified	Absent to 5 ft thick; coarse-grained on uplands; fine-grained organic on lowlands	Beach ridges, p. 126
Parallel radial	Crested; relief up to several hundred feet	Gullies V-type, steep grades	Volcanic ejecta; ash, lapilli, cinders, blocks	Absent to very thick; coarse- to fine-grained, stratified	Pyroclastic cones, p. 130
			Consolidated Materials		
Swallow hole; locally dendritic; rare through-flowing streams	Undulating or blocky; basins rare to common; relief less than 50 ft	Gullies common; C-type or V-type	Limestone; strata horizontal	None to 15 ft thick; fine-grained, permeable if undisturbed	Limestone plains, p. 135
Regionally dendritic; locally pinnate; channels closely spaced	Rolling; slopes smoothly sigmoid; relief less than 400 ft; valley bottoms flat	Gullies common; C-type if relief low, V-type if relief high	Shale; strata horizontal	2 to 3 ft thick; fine-grained	Shale plains in humid areas, p. 138
Regionally dendritic or parallel; locally pinnate	Crested; slopes straight, up to 30°; relief less than 500 ft; valley bottoms flat	Gullies incredibly numerous; V-type in arid regions, F-type in semiarid	Shale; strata horizontal	Absent or very thin; fine-grained	Shale plains in arid and semiarid regions, p. 138
Regionally dendritic; locally rectangular or trellis	Rolling; valley bottoms slightly concave upward; relief less than 500 ft	Gullies rare; V-type, steep grade; rare deflation basins	Sandstone; strata horizontal	1 to 10 ft thick; mostly coarse-grained, permeable	Sandstone plains, p. 142
Regionally dendritic; slightly pinnate locally	Blocky; "scarplets" on valley sides; relief less than 500 ft; valley bottoms flat	Gullies have "stepped" profiles; V-type or C-type with C-type generally on upper topographic high surfaces	Shale and limestone; strata horizontal	2 to 6 ft thick; fine-grained	Limestone-shale plains, p. 145
Regionally dendritic; locally pinnate, rectangular	Blocky; "scarplets" on slopes; relief less than 500 ft	Gullies V-type; two-layered	Shale and sandstone; strata horizontal	2 to 6 ft thick; coarse- to fine-grained, relatively impermeable	Sandstone-shale plains, p. 147
Swallow hole on uplands; lowlands have through-flowing streams	Blocky, crested; basins common; relief exceeds 500 ft; steep valley walls; valley floors flat	Gullies rare; C-type, rockfalls common	Limestone; strata horizontal	2 to 15 ft thick on uplands; fine-grained, permeable if undisturbed; thin or absent on valley side	Limestone plateaus, p. 153
Regionally dendritic; locally dendritic, rectangular, parallel	Blocky, crested; valley bottoms slightly concave upward; valley cross section usually opened U- or V-shaped	Gullies rare; V-type, steep grade	Sandstone; strata horizontal	3 to 5 ft thick; coarse- to fine-grained	Sandstone plateaus, p. 156
Regionally dendritic; locally dendritic, rectangular, parallel	Blocky, crested; "scarplets" on valley sides; slopes steep	Gullies V-type; steep grades; "stepped" profiles; sheet and rill erosion common	Interbedded shales and sandstone; strata horizontal	2 to 6 ft thick on uplands; coarse-grained; thin to absent on valley sides	Sandstone-shale plateaus, p. 159
Regionally trellis; locally trellis, dendritic, swallow hole, parallel	Rolling; small elongate basins; ridges mostly asymmetric	Gullies rare; C-type; rockfalls common at base of valley sides	Limestone; may include thin shale or sandstone beds; strata inclined	Thin on uplands; thick on lowlands; fine-grained, permeable if undisturbed	Limestone hills (humid climate), p. 163
Regionally trellis; locally trellis, dendritic, parallel; channels braided	Crested; ridges steep, rough, "broken," mostly asymmetric	Gullies V-type, steep; "stepped" profiles; rockfalls common	Limestone; thin shale or sandstone beds; strata inclined	Thin or absent on uplands; stony	Limestone hills (arid climate), p. 163

(Continued)

Table 8 (Concluded)

Landscape Elements				Interpretive Elements	
Drainage	Topography	Local Erosion	Parent Materials	Soil Profile	Representative Landscape
			Consolidated Materials (Continued)		
Trellis; locally parallel	Rolling; ridges mostly asymmetric	Gullies rare; C-type; rockfalls common on steep slopes	Dolomite; interbedded shale or sandstone; strata inclined	Thin on uplands; stony; thick on lowlands, silty, clayey	Dolomite hills (humid climate), p. 166
Trellis	Rolling; ridges subdued	Gullies generally C-type; some broadly V-type	Shale; thin interbeds of sandstone or limestone; strata inclined	Thin on uplands; fine-grained; includes shale chips; 2 to 5 ft thick on lowlands; fine-grained	Shale hills (humid climate), p. 167
Trellis	Crested; slopes straight, less steep than limestone	Gullies generally C-type; some V-type, steep grade	Shale; thin interbeds of sandstone or limestone; strata inclined	Thin or absent; mostly shale chips	Shale hills (arid climate), p. 168
Regionally trellis; dendritic on valley floors	Crested; ridges minutely serrate at crest	Gullies rare; C-type shaped or broadly V-type; rockfalls common on steep slopes	Mostly sandstone in ridges; mostly shale in lowlands	Thin to thick; coarse-grained on uplands; fine-grained on lowlands	Sandstone-shale hills, p. 170
Trellis; dendritic on floors of large valleys	Rolling, crested; valley floors undulating	Gullies rare on uplands; V-type; profiles commonly "stepped"; rockfalls common on steep slopes; gullies on lowlands C-type	Ridges mostly limestone; valleys mostly shale	Thin on uplands; stony; 3 to 7 ft thick in lowlands; fine-grained	Limestone-shale hills, p. 173
Swallow hole, deranged; through-flowing streams deeply incised	Regionally blocky; locally rolling, many basins; surface rough, botryoidal; large valleys steep-sided; columnar jointing common	Gullies rare; V-type, grades moderate	Basalts, andesites, rarely rhyolites; strata horizontal	1 to 10 ft thick; sand, sandy silt, silty clay	Basalt plains and plateaus, p. 176
Dendritic, rectangular; low-order channels "surround" uplands	Rolling, valley sides sigmoid; uplands randomly arranged	Gullies mostly compound; C-type near heads; V-type near mouths; sheet erosion common	Granite and granite-like rocks; nonstratified	6 to 10 ft thick; silty sand; clayey sand; finer grained in lowlands	Granite hills, p. 180
Dendritic; trellis	Rolling, crested; valley floors flat	Gullies C-type on gentle slopes; V-type on steep slopes	Slates, phyllites; strata horizontal	2 to 4 ft thick; fine-grained; relatively impermeable	Slate hills, p. 183
Dendritic; strongly resembles pattern typical of granitic areas; "enclosed" areas oval, rectangular	Rolling; valley sides sigmoid; tendency toward preferred orientation	Gullies compound; C-type near heads; V-type near mouths	Gneiss and gneiss-like rocks; nonstratified	8 to 15 ft thick; silty, sand; finer grained in lowlands	Gneiss hills, p. 185
Regionally dendritic; locally rectangular, dendritic, trellis	Rolling where relief is low; crested where relief is high; uplands tend to be angular	Gullies V-type	Schistose rocks; nonstratified; chlorite, talc, hornblende schists if uplands rounded and subdued; quartzose schists if uplands angular	6 to 12 ft thick; coarse- to fine-grained; finer grained in lowlands	Schist hills, p. 187

(Sheet 3 of 3 sheets)

Table 9

Classification of Landscape Types Formed Chiefly of Unconsolidated Materials

Landscapes formed in unconsolidated materials deposited by:

Eolian processes (stratified or nonstratified)
- 59 (Dune fields)*
- 64 (Loess surfaces)

Glacial processes (nonstratified or very crudely stratified)
- 69 (Ground moraines)
- 75 (Ridge moraines)
- 79 (Kettle-kame moraines)
- 84 (Drumlin fields)
- 86 (Eskers and kames)

Fluvial processes (crudely to well stratified)
- 88 (Alluvial fans and aprons)
- 93 (Outwash surfaces)
- 96 (Floodplains)
- 103 (Deltaic surfaces)
- 107 (Terraces)
- 110 (Coastal alluvial plains)

Lacustrine processes (well stratified)
- 116 (Beds of perennial lakes)
- 120 (Beds of ephemeral lakes)

Littoral processes (crudely to well stratified)
- 124 (Tidal flats)
- 126 (Beach ridges)

Volcanic processes (well stratified)
- 130 (Pyroclastic cones)

* Terms in parentheses are the titles of landscapes as described in Part V, and numbers preceding parentheses denote page on which the specific landscape is described in detail. The listed examples do not include all possible types.

Table 10

Classification of Landscape Types Formed Chiefly of Consolidated Materials

Landscapes formed in consolidated materials of the following rock types:

- Sedimentary rocks
  - Stratified
    - Bed horizontal or nearly so
      - Plains
        - 135 (Limestone)*
        - 138 (Shale)
        - 142 (Sandstone)
        - 145 (Limestone-shale)
        - 147 (Sandstone-shale)
        - 150 (Sandstone-shale-limestone)
      - Plateaus
        - 153 (Limestone)
        - 156 (Sandstone)
        - 159 (Sandstone-shale)
    - Beds inclined
      - Hills or mountains
        - 162 (Limestone)
        - 165 (Dolomite)
        - 167 (Shale)
        - 170 (Sandstone-shale)
        - 173 (Limestone-shale)
- Igneous rocks
  - Stratified
    - 176 (Basalt)
  - Nonstratified
    - Hills or mountains
      - 180 (Granitic)
- Metamorphic
  - Stratified
    - Hills
      - 183 (Slate)
  - Nonstratified
    - Hills
      - 185 (Gneiss)
      - 187 (Schist)

* Terms in parentheses are the titles of landscapes as described in Part VI, and numbers preceding parentheses denote page on which the specific landscape is described in detail. The listed examples do not include all possible types.

Table 11

Procedure for Airphoto Analysis

Step 1:	Select study area and define purpose of study
Step 2:	Assemble photomosaic
Step 3:	Tabulate general background data
a.	Geological and geomorphic
b.	Climatic
c.	Vegetation
d.	Soils
e.	Cultural
f.	Land use
Step 4:	Inspect for photo quality
a.	Make estimate of potential reliability
b.	Determine photo factors likely to make interpretation difficult
Step 5:	Inspect mosaic for regional patterns
a.	Classify regional drainage type
b.	Delineate regions of similar land use and vegetation patterns
c.	Delineate regions of similar cultural activity
Step 6:	Delineate homogeneous areas, and define as regions
Step 7:	Select specific areas for detailed study
Step 8:	Study specific areas stereoscopically, and refine regional boundaries
a.	Classify regional drainage types and channel types
b.	Classify surface configuration
c.	Classify gully types
d.	Describe vegetation types
e.	Describe cultural activities, both land use and construction
Step 9:	Erect new regions if needed, or combine regions if appropriate
Step 10:	Tabulate physical characteristics of each region
Step 11:	Classify the landscape type of each region
Step 12:	Identify parent materials and soil types
Step 13:	Tabulate probable minor characteristics of soil and landscape types
Step 14:	Examine each region in detail for presence of minor characteristics
Step 15:	Refine boundaries or regional definitions, if necessary
Step 16:	Estimate soil trafficability characteristics of each region
Step 17:	Examine stereoscopically for evidence of obstacle factors
a.	Vegetation
b.	Microrelief features
c.	Construction features
d.	Hydrographic features
Step 18:	Tabulate obstacle factors in each region
Step 19:	Subdivide regions on basis of obstacle factors, if necessary
Step 20:	Tabulate terrain trafficability characteristics of each region
Step 21:	Construct final terrain trafficability map

Table 12

Terrain Trafficability Characteristics of Part of Hart County, Kentucky

Region	Rating Cone Index* Topographic Highs	Rating Cone Index* Topographic Lows	Slopes, % Characteristic	Slopes, % Maximum	Surface Characteristics** Ditches	Surface Characteristics** Cut and Fill Banks	Surface Characteristics** Gullies	Traverse† in miles	"Stepped" Surface	Trees††	Shrubs‡	Hydrographic Characteristics‡‡
1'a	125	125	<20	50	b	b	d	0.4	e	D	C	2
1'b	125	125	<20	50	c	c	d	0.5	c	B	B	2
2'a	120	120	<30	100	b	b	d	0.3	e	C	C	2
2'b	120	120	<50	100	c	c	d	0.4	a	B	B	1
3'a	140	45	<30	60	b	b	b	0.3	d	C	C	2
3'b	140	45	<40	60	c	c	c	0.4	a	A	B	1
4'	60	35	<5	60	d	d	d	0.7	e	C	C	3
5'	140	45	<30	60	b	b	b	0.4	e	C	C	2
6'	300+	300+	<5	15	a	a	e	0.1	b§	C	C	1

* The RCI given is the minimum probable value during the wet season.

** These features must, in general, include slopes greater than 1 ft in height and steeper than 60%. The scale of values is as follows:

- a: Numerous.
- b: Common.
- c: Present but not common.
- d: Rare.
- e: Absent.

† Mean distance in miles between gullies, ditches, or cut and fill banks along a random straight line.

†† The scale of values for tree density is:

- A: Dense; passable, but path tortuous.
- B: Moderately dense; passable, but path length substantially extended.
- C: Patches and rows; path length slightly extended.
- D: Rare or absent; no appreciable effect on path length.

‡ The scale of values for shrub density is:

- A: Dense; visibility seriously inhibited; path selection difficult.
- B: Moderately dense; visibility somewhat inhibited; path selection not seriously inhibited.
- C: Rare or absent; visibility not appreciably affected; path selection easy.

‡‡ The scale of values for hydrographic features is:

- 1: Surface water absent.
- 2: Small ponds, easily bypassed.
- 3: Unfordable water barrier subdivides region.

§ Curbs, terraces, walls, etc.

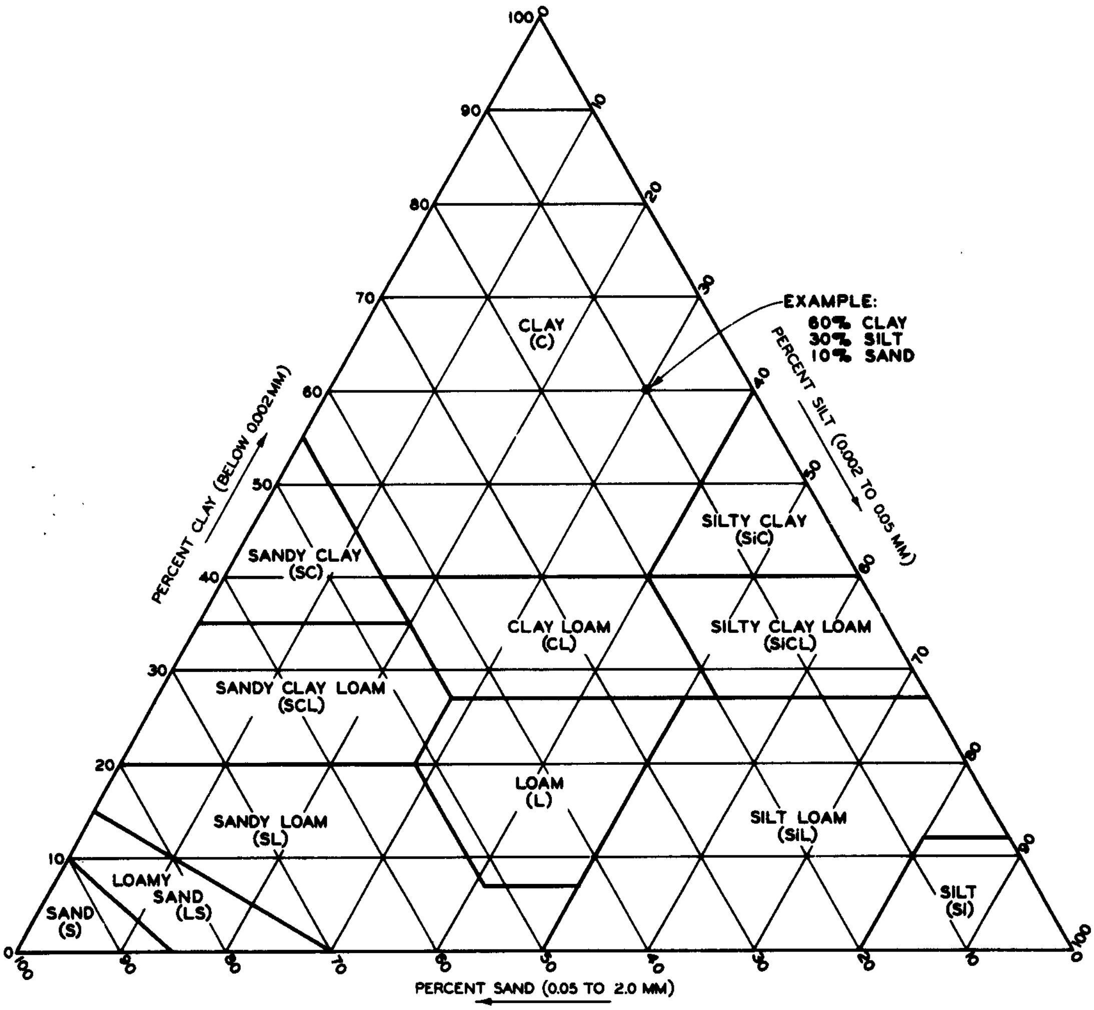
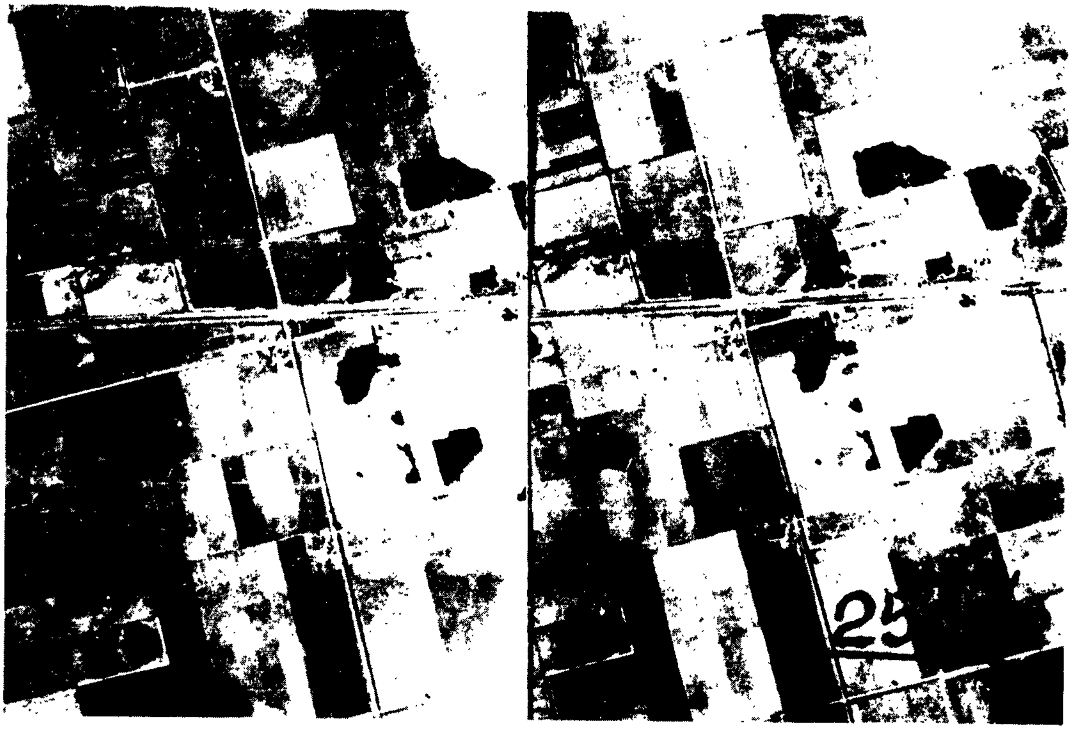
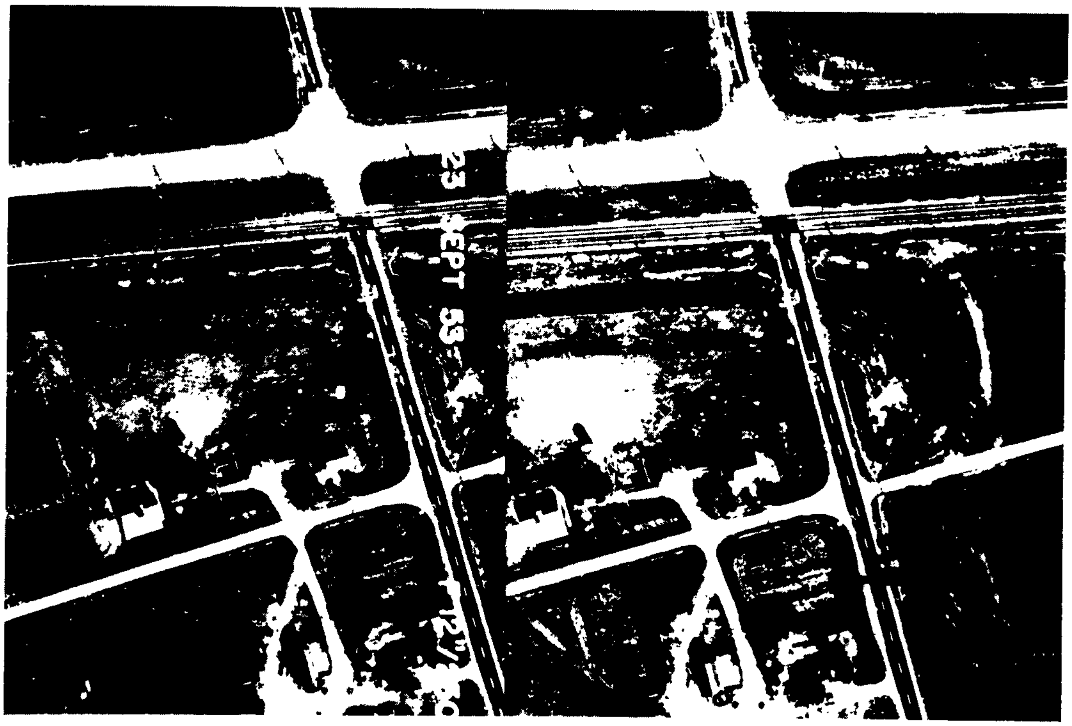


Fig. 1. USDA soil textural classification

Fig. 2. Difference in tone. The dark horizontal lines are caused by tillage operations. La Porte County, Indiana, 27 May 1953

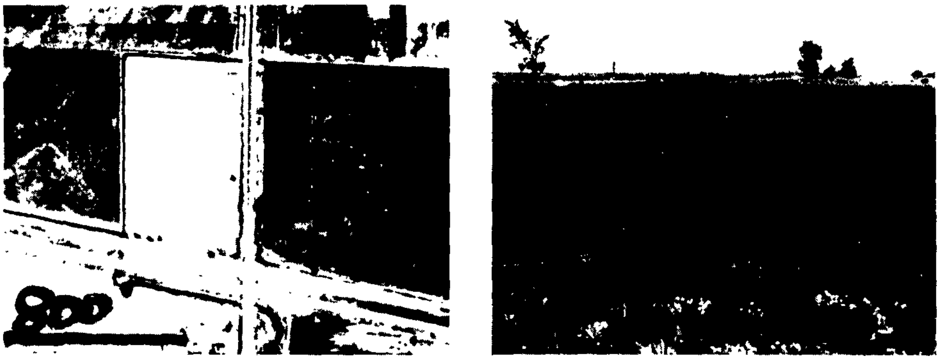


a. Stereopair of 12-in. focal length photos at scale of 1:30,000



b. Stereopair of 12-in. focal length photos at scale of 1:2400

Fig. 3. Variation of photo images and photo texture with change in scale (U. S. Air Force photos)

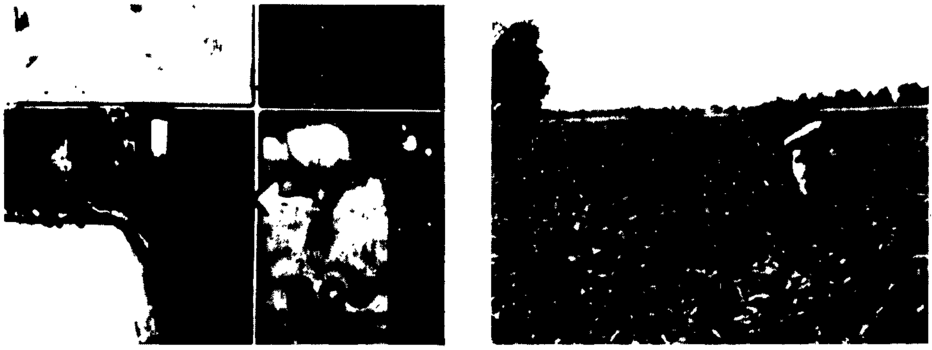


a. 18 May 1954

b. 7 October 1953

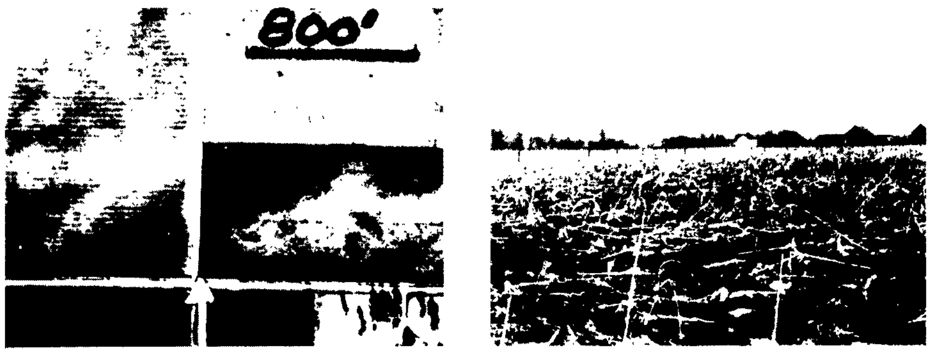
c. 18 May 1954

Fig. 4. Illustrations of tone and texture, La Porte County, Indiana

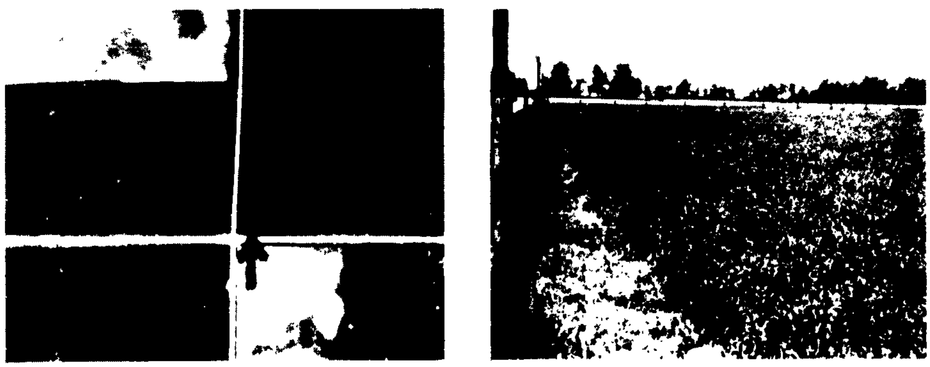


a. 28 May 1953

b. 20 May 1954



c. 17 December 1952



d. 20 May 1954

Fig. 5. Illustrations of tone and texture, Tipton County, Indiana

Fig. 6. Gully erosion and foliage differences. Winter appearance, Gibson County, Indiana, December 1952

Fig. 7. Gully erosion and foliage differences. Summer appearance, Gibson County, Indiana, June 1953

a. Stereopair of 6-in. focal length photos

b. Stereopair of 12-in. focal length photos

Fig. 8. Effect on apparent relief of change in focal length of camera (U. S. Air Force photos)

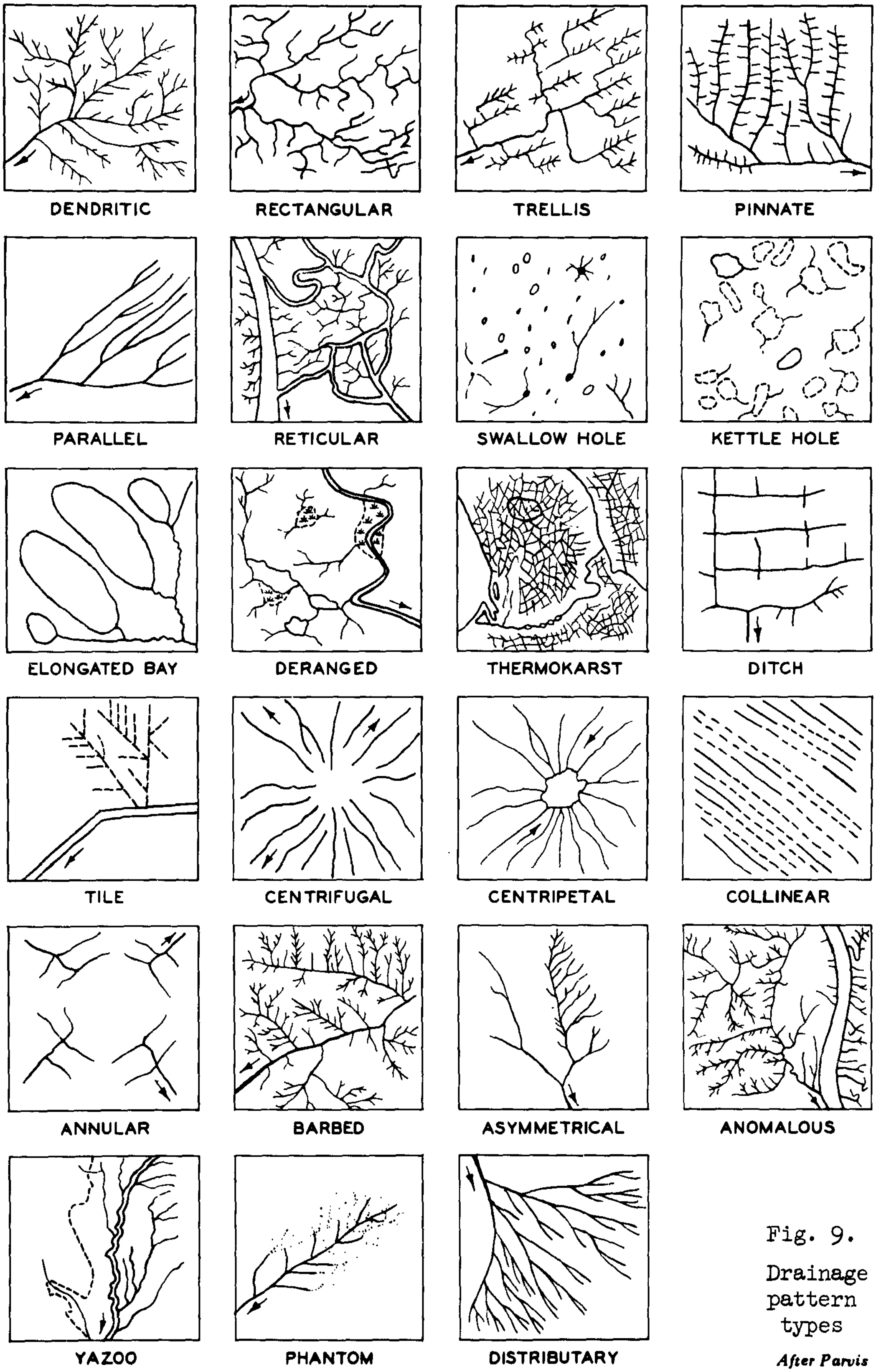


Fig. 9.
Drainage pattern types

After Parvis

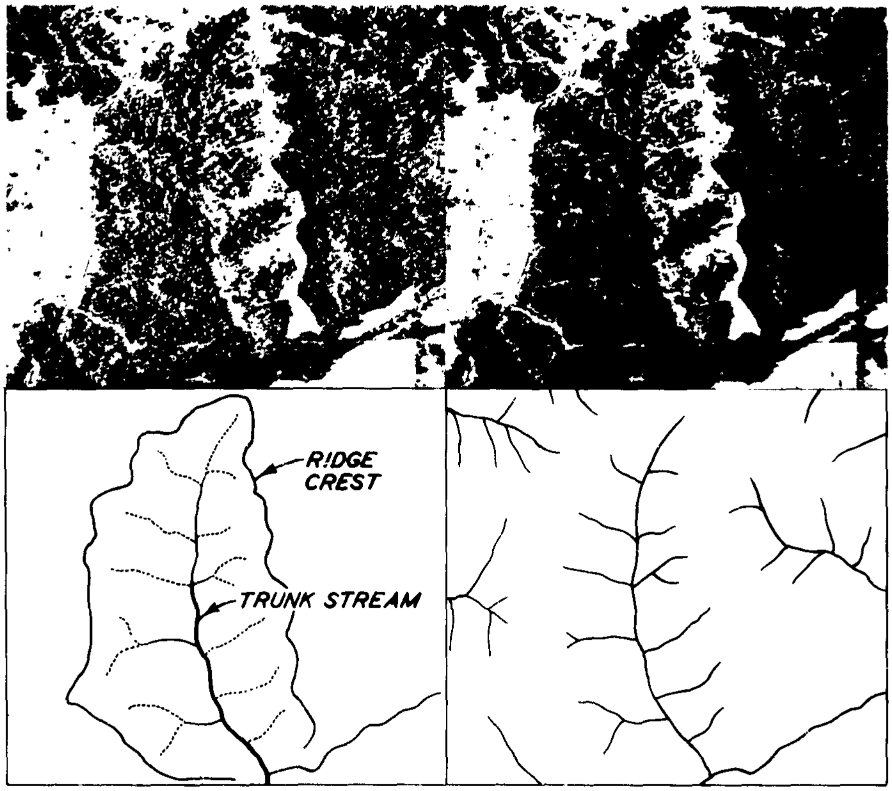


Diagram A Diagram B

Photograph: Warren County, Mississippi, 30 December 1956

Drainage pattern: Pinnate, slightly asymmetric

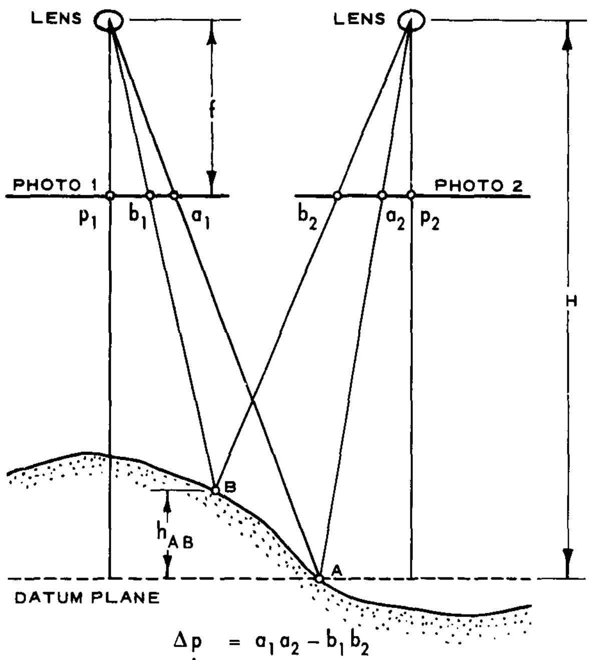
Parent materials: Deep, homogeneous, unconsolidated silt (loess)

Diagram A: stream order

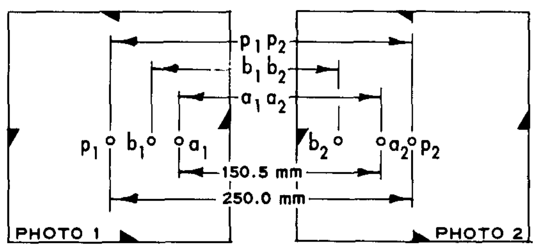
Streams are ordered from the headwaters downstream. The first clear scour channel is order 1; the junction of two order 1 channels produces an order 2 stream, and so on. Thus, on the diagram: a dotted line indicates an order 1 (first order) stream; a thin solid line indicates an order 2 (second order) stream; a heavy solid line indicates an order 3 (third order) stream. Note that the junction of a first order and a second order stream does <u>not</u> produce a third order stream.

Diagram B: tracing of drainage pattern from photograph.

Fig. 10. Drainage pattern terminology



$$\Delta p = a_1 a_2 - b_1 b_2$$
$$b_A = p_1 p_2 - a_1 a_2$$
$$b_B = p_1 p_2 - b_1 b_2$$



FIND: $h_{AB} = \dfrac{H(\Delta p)}{b_A + \Delta p}$

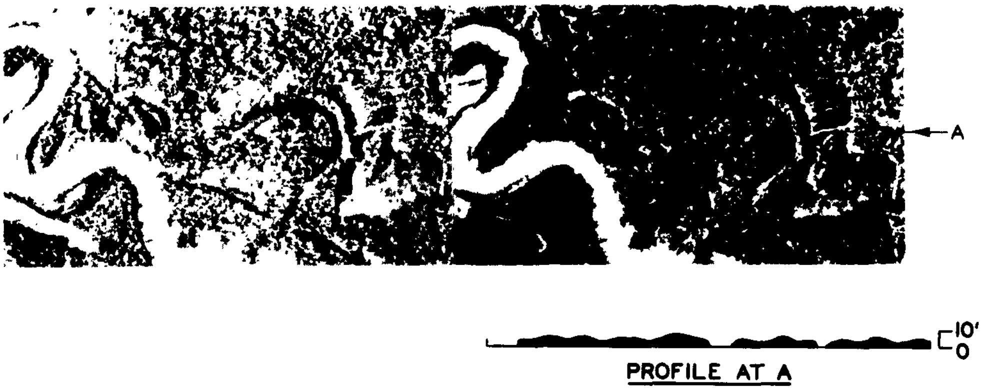
GIVEN: ALTITUDE IN FEET, H

MEASURE: DIFFERENCE IN PARALLAX, Δp
PHOTO BASE, b_A

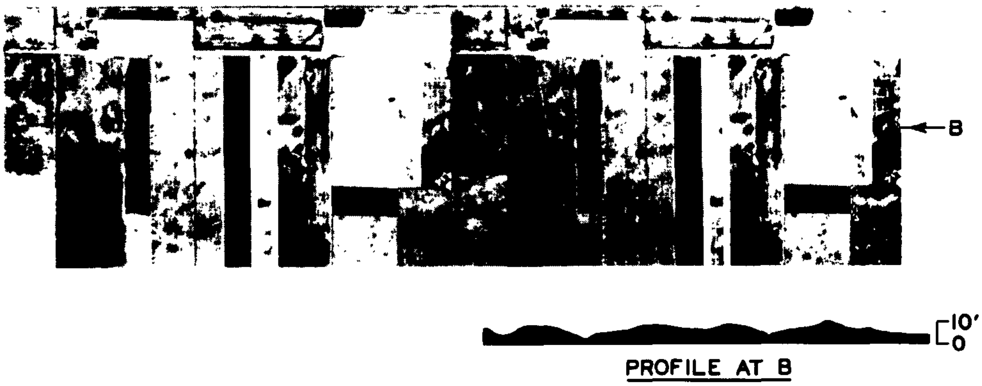
PROCEDURE:

1. LOCATE PRINCIPAL POINTS OF PHOTOS 1 AND 2 BY INTERSECTION OF FIDUCIAL AXES.
2. STEREOSCOPICALLY TRANSFER THE PRINCIPAL POINT OF PHOTO 1 TO PHOTO 2 AND THE PRINCIPAL POINT OF PHOTO 2 TO PHOTO 1.
3. OVERLAP THE TWO PHOTOGRAPHS SO THAT COMMON PHOTO IMAGES ARE SUPERIMPOSED. MEASURE TO NEAREST 1/100 IN. THE DISTANCE BETWEEN LEFT FIDUCIAL MARK OF PHOTO 1 AND LEFT FIDUCIAL MARK OF PHOTO 2. THIS DISTANCE IS THE PHOTO BASE b_A.
4. SEPARATE THE PHOTOS ALONG LINE OF FLIGHT SUFFICIENT DISTANCE TO OBSERVE ALL IMAGES, AND MAINTAIN A STRAIGHT ALIGNMENT OF THE FOUR POINTS OF STEPS 1 AND 2.
5. A MORE EXACT MEASUREMENT OF THE PHOTO BASE b_A MAY BE MADE BY MEASUREMENT OF $p_1 p_2$ AND $a_1 a_2$ WHERE $b_A = p_1 p_2 - a_1 a_2$.
6. THE DIFFERENCE IN PARALLAX $\Delta p = a_1 a_2 - b_1 b_2$. IF THE DIFFERENCE IN PARALLAX IS POSITIVE THE DIFFERENCE IN ELEVATION IS ABOVE POINT A, AND IF NEGATIVE THE DIFFERENCE IN ELEVATION IS BELOW POINT A.
7. THE FORMULA IS EXACT FOR TRULY VERTICAL STEREOSCOPIC PHOTOGRAPHS EXPOSED FROM THE SAME ALTITUDE. THESE IDEAL CONDITIONS ARE SELDOM, IF EVER, REALIZED IN PRACTICE. HOWEVER, FOR LOW TILTS (3° OR LESS) FAIRLY GOOD RESULTS ARE OBTAINABLE FOR TRAFFICABILITY STUDIES.

Fig. 11. Photogrammetric relations



a. Undulating and basined: Hinds County, Mississippi, 30 December 1956



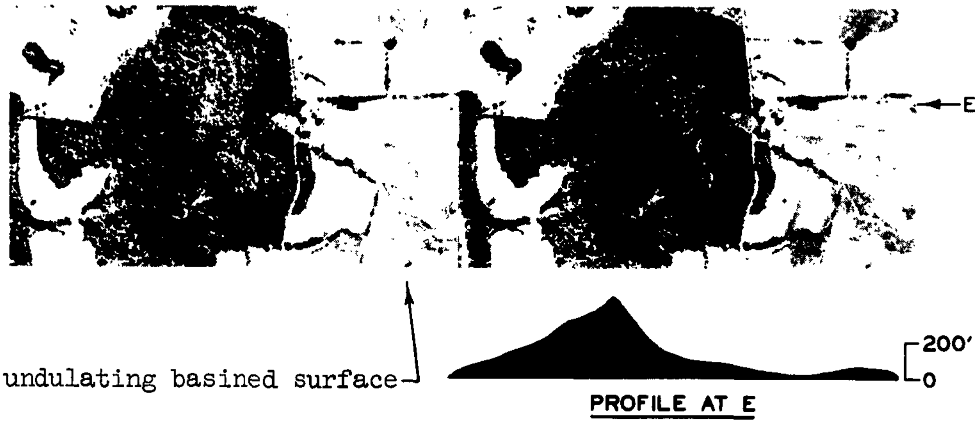
b. Undulating and basined: Walworth County, Wisconsin, 2 October 1956

c. Rolling and basined: Hart County, Kentucky, 28 August 1958

Fig. 12. Examples of surface configurations, scale 1:20,000

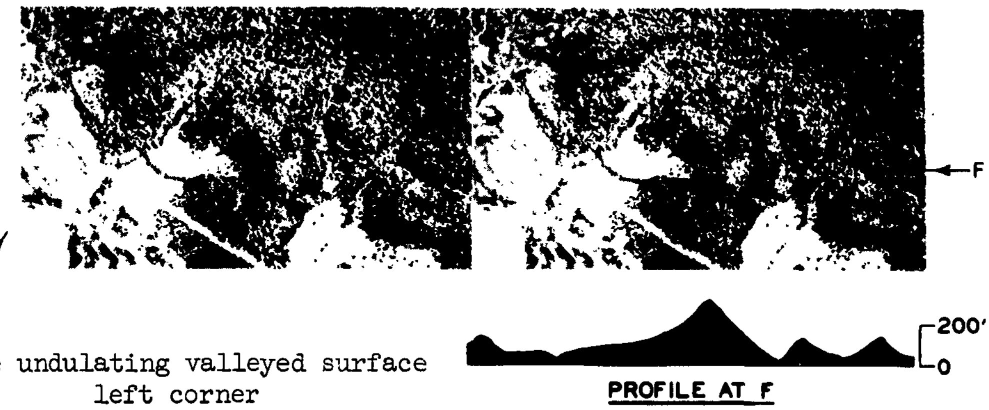
Sheet 1 of 3 sheets

d. Rolling and valleyed: Sequatchie County, Tennessee, 23 April 1959



Note undulating basined surface

e. Crested: Hart County, Kentucky, 28 August 1958

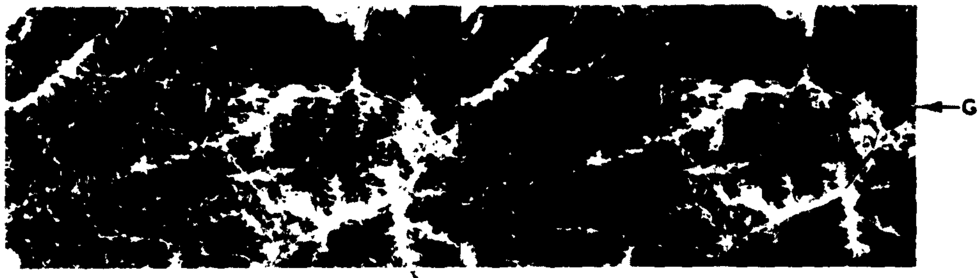


Note undulating valleyed surface
left corner

f. Crested and valleyed: Sequatchie County, Tennessee, 23 April 1959

Fig. 12. Examples of surface configurations, scale 1:20,000

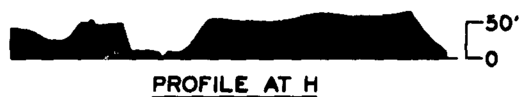
Sheet 2 of 3 sheets



Note tendency toward blocky surface on bare-topped ridges

g. Crested and valleyed: Warren County, Mississippi, 30 December 1956

Note that minor ridges on flanks of topographic highs are crested surfaces

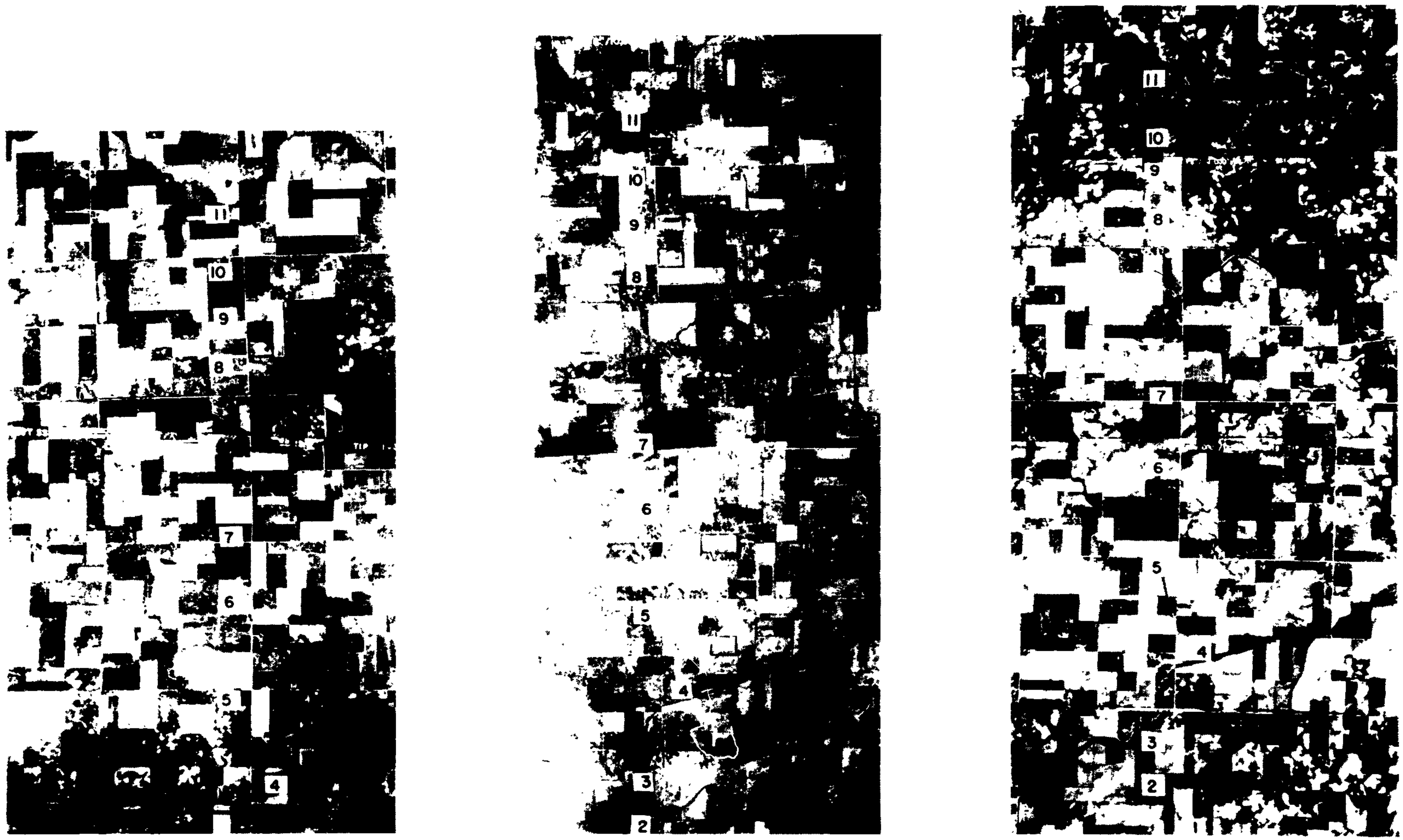


h. Blocky and valleyed: Warren County, Mississippi, 30 December 1956

Note undulating valleyed surface in topographic low, and rolling basined surface on topographic highs

i. Blocky and valleyed: Hart County, Kentucky, 28 August 1958

Fig. 12. Examples of surface configurations, scale 1:20,000



13 October 1953 17 December 1952 20 May 1954

Fig. 13. Seasonal changes in appearance of field patterns, Tipton County, Indiana, scale 1:62,500

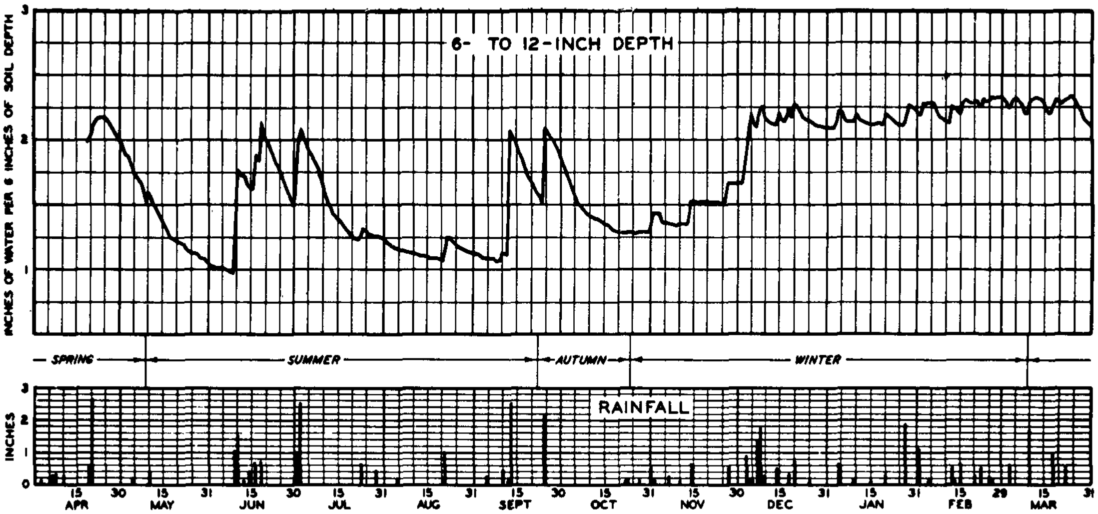


Fig. 14. Record of daily soil moisture for a clay soil, Mound, Louisiana (climate D-2; see Appendix B)

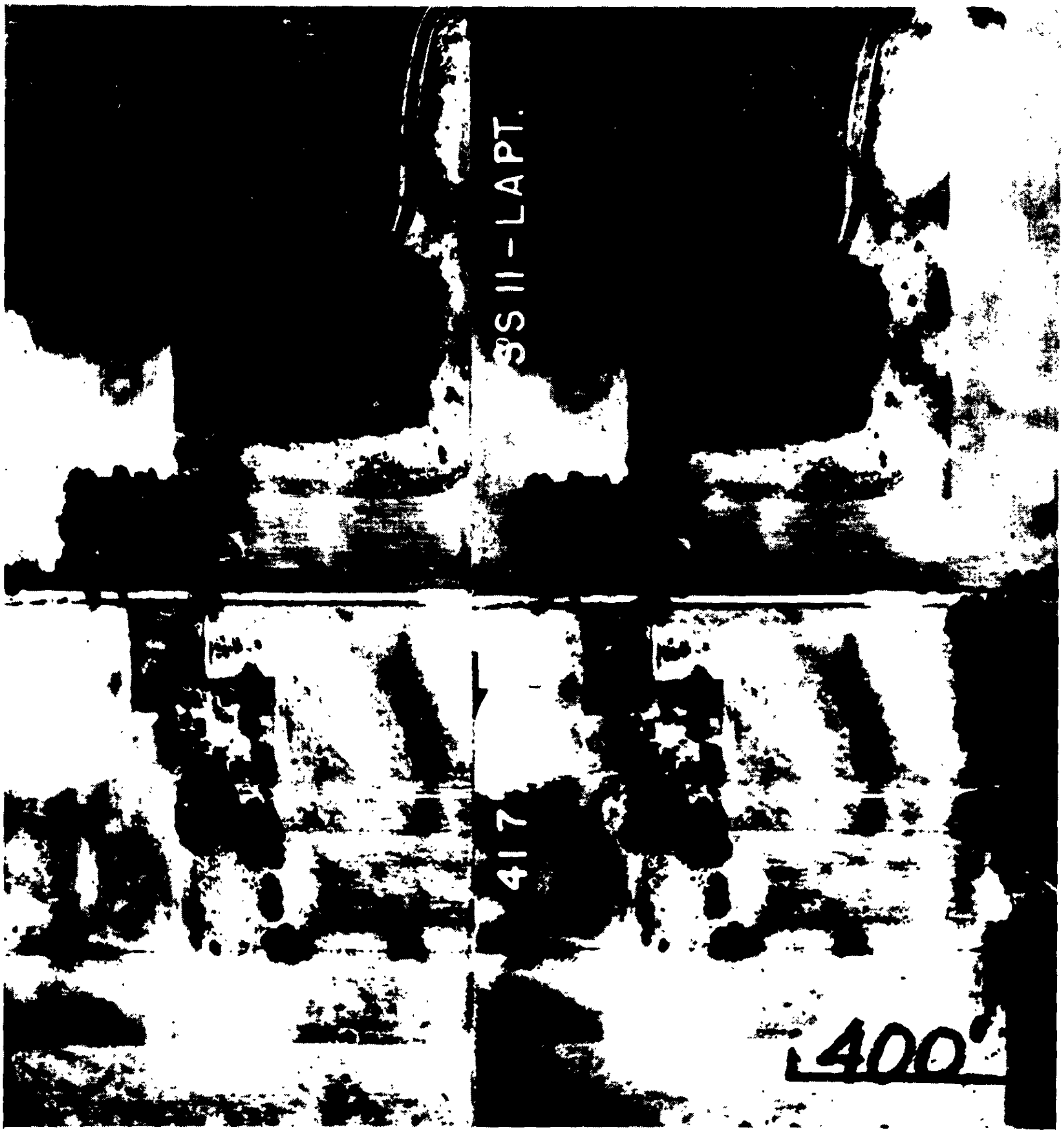


Fig. 15. Dune field, La Porte County, Indiana (climate C-2)

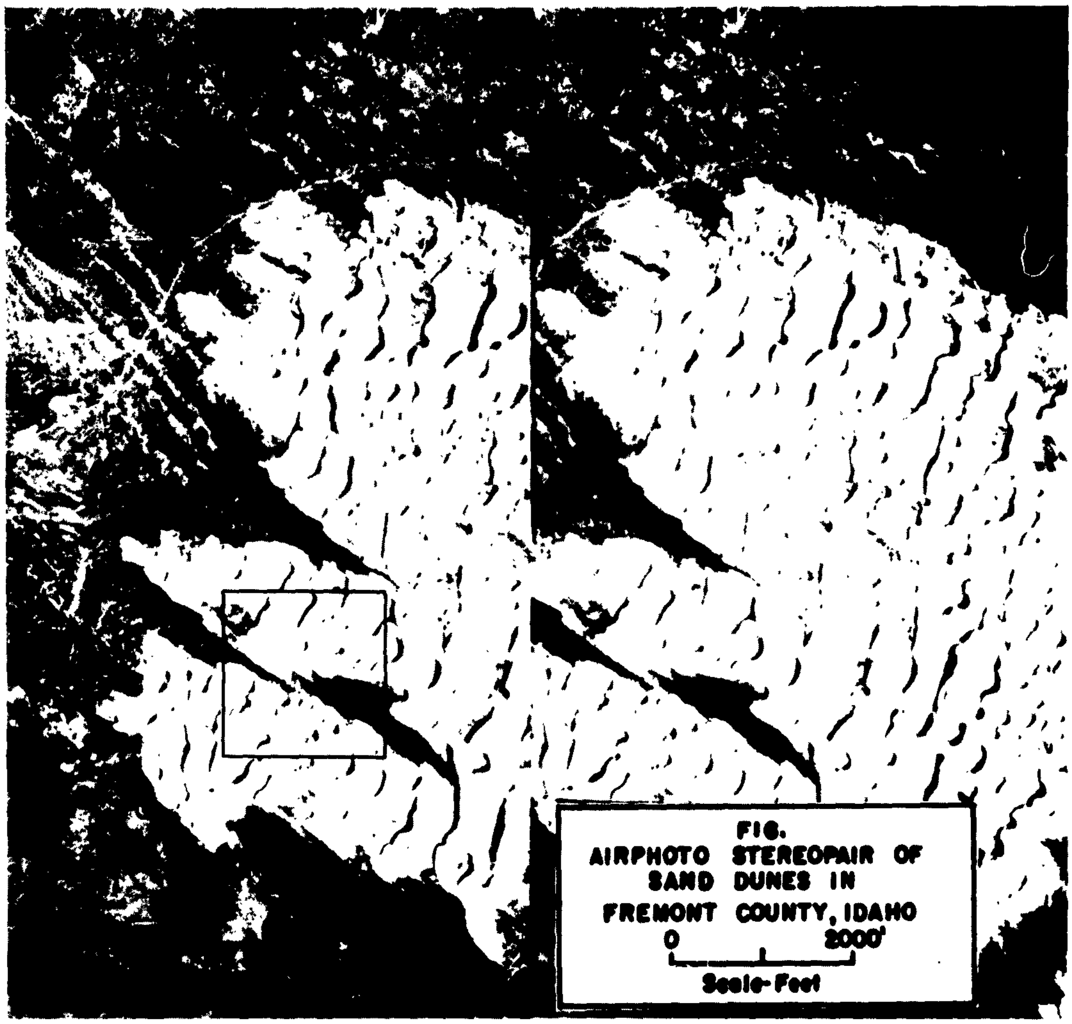


Fig. 16. Dune field, Fremont County, Idaho (climate C-3)

Fig. 17. Dune field, Lincoln County, Nebraska (climate C-2)

Fig. 18. Dune field, Porter County, Indiana (climate C-2)

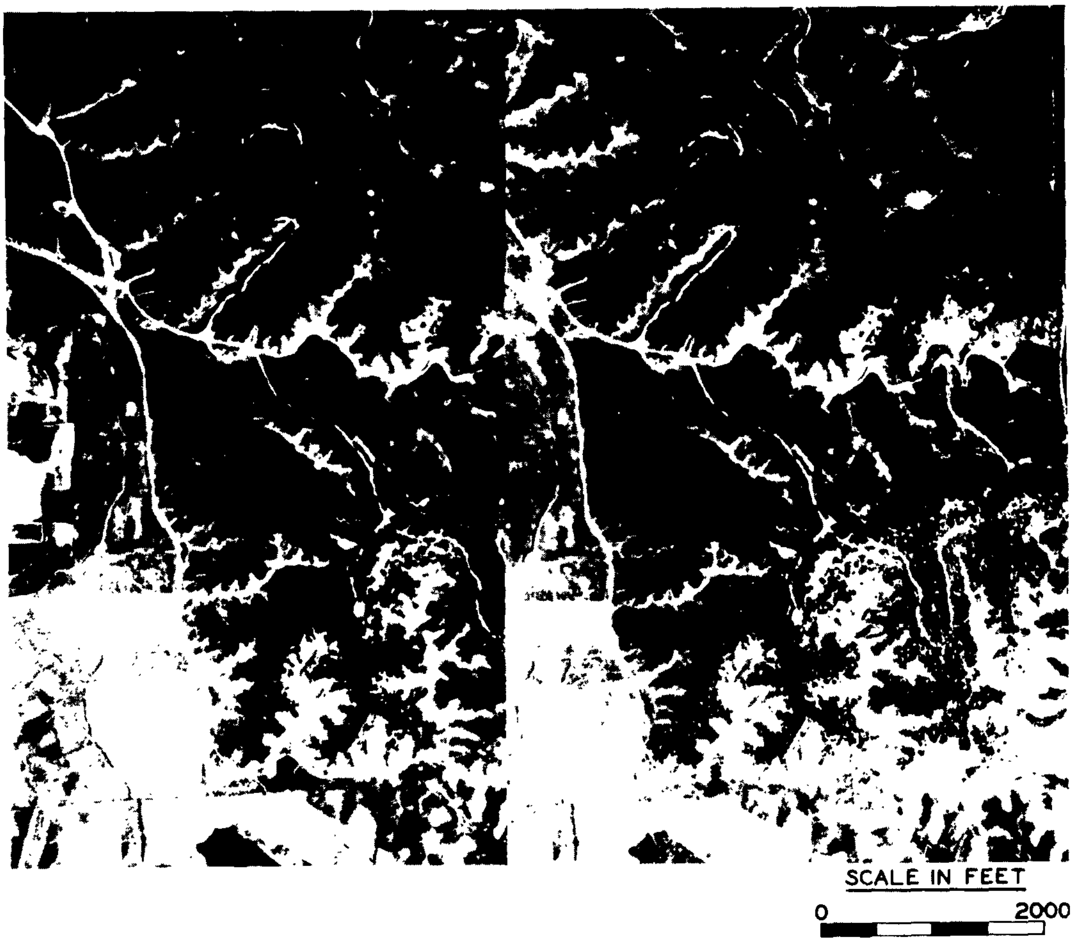


Fig. 19. Loess surface, Woodbury County, Iowa (climate C-2)

Fig. 20. Loess surface, Buffalo County, Nebraska (climate C-2)

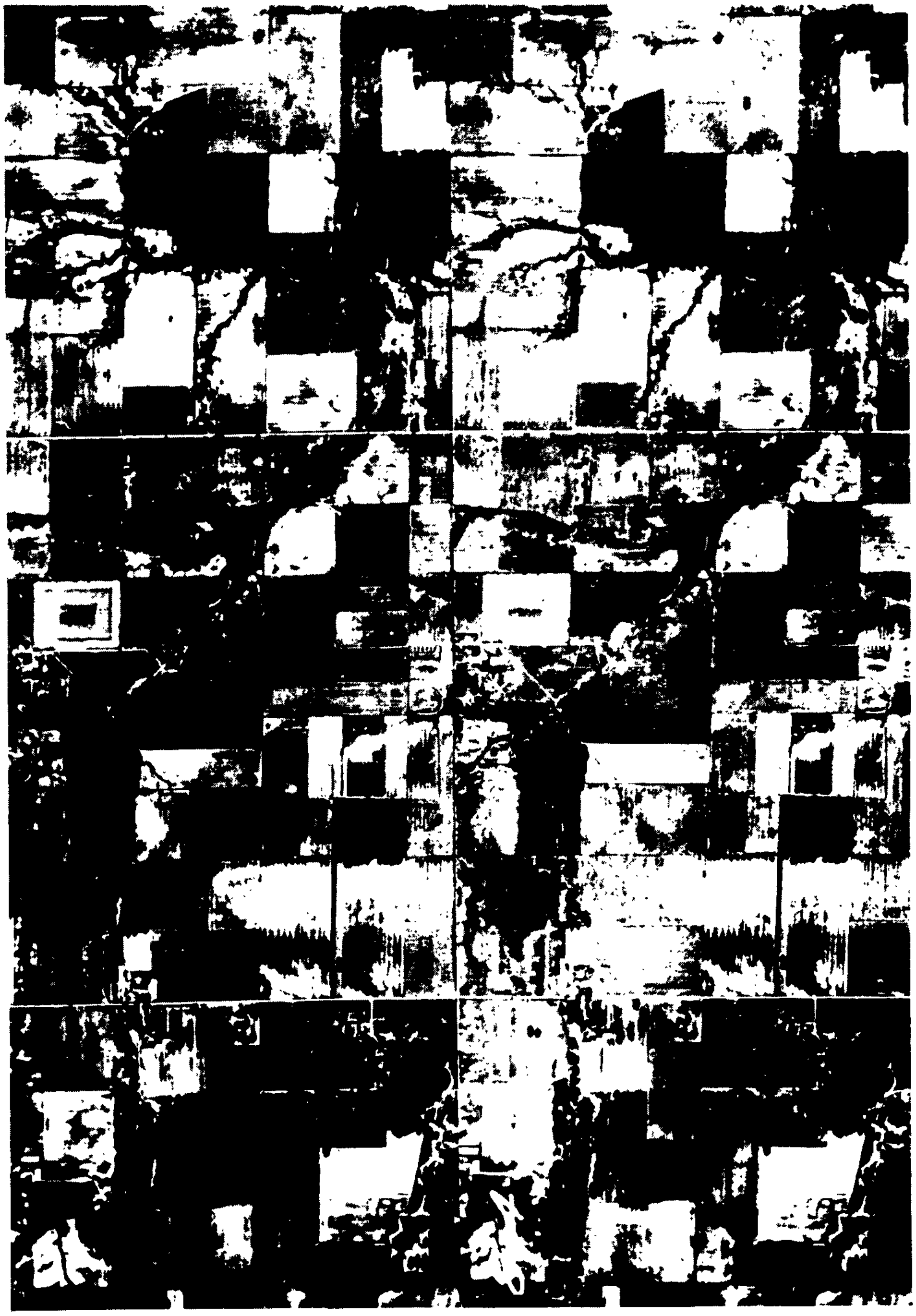


Fig. 21. Old ground moraine (Illinoian stage), southern Indiana
(climate D-2)

Fig. 22. Young ground moraine (Wisconsin stage), Champaign County, Illinois (climate D-2)

Fig. 23. Young ground moraine (Wisconsin stage), Benson County, North Dakota (climate C-3)

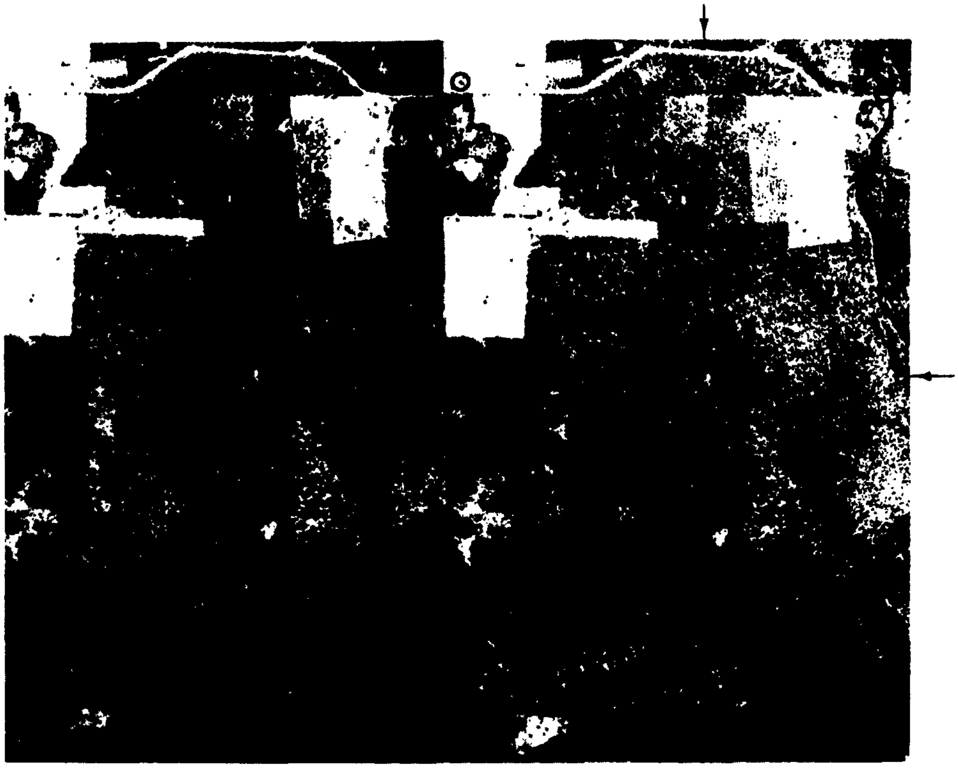


Fig. 24. Ridge moraine, Crawford County, Michigan (climate C-2)

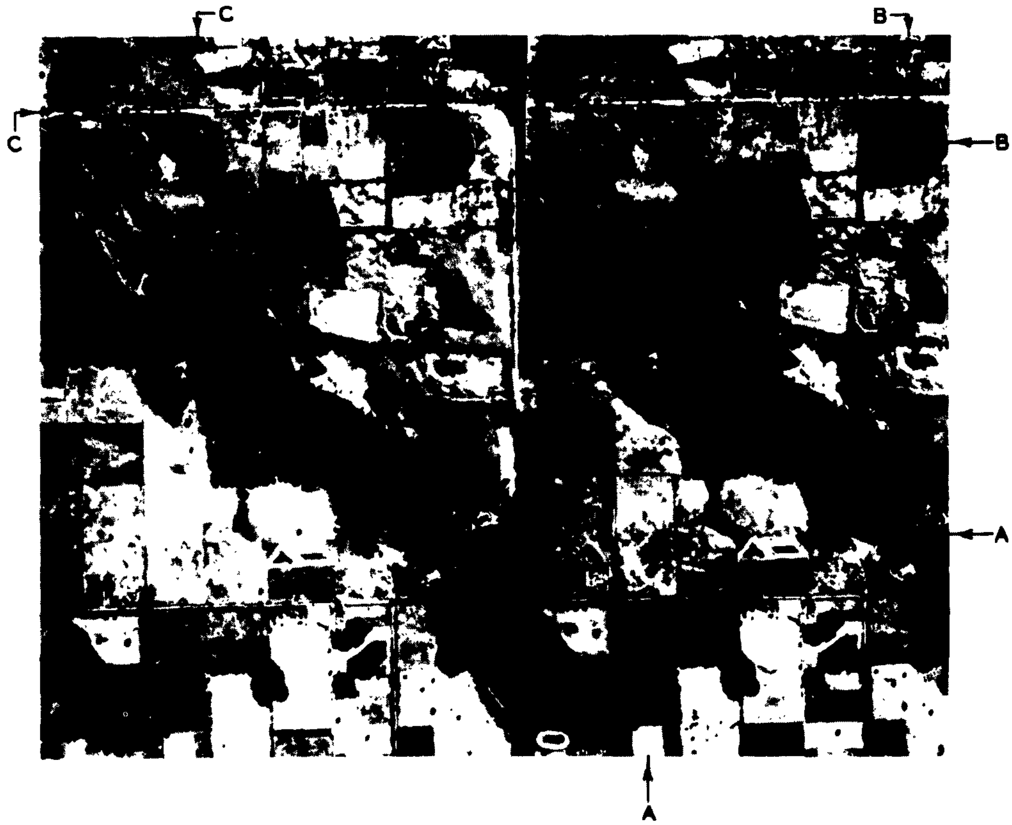


Fig. 25. Kettle-kame moraine, Barry County, Michigan (climate C-2)

Fig. 26. Drumlin field, Dane County, Wisconsin (climate C-2)

Fig. 27. Eskers (opposite marginal arrows) with poorly developed kames in upper left corner, Walworth County, Wisconsin, 2 October 1956, scale 1:20,000

Fig. 28. Alluvial fan and alluvial apron, Death Valley, California (climate D-4)

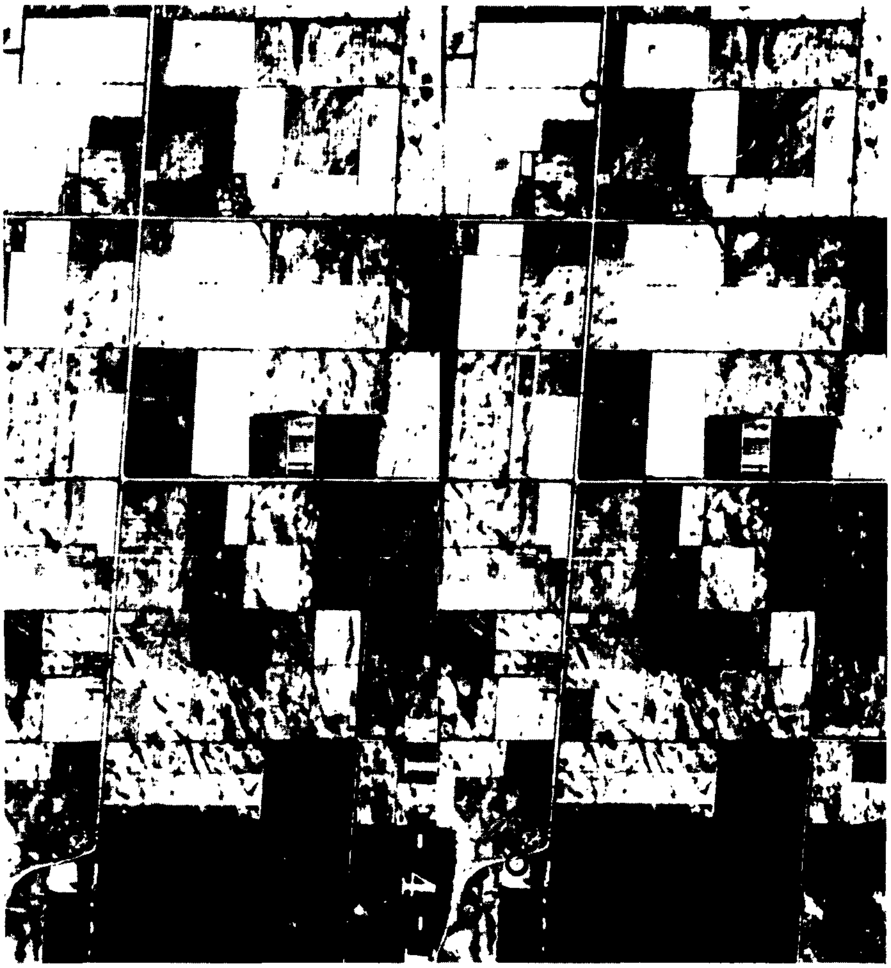
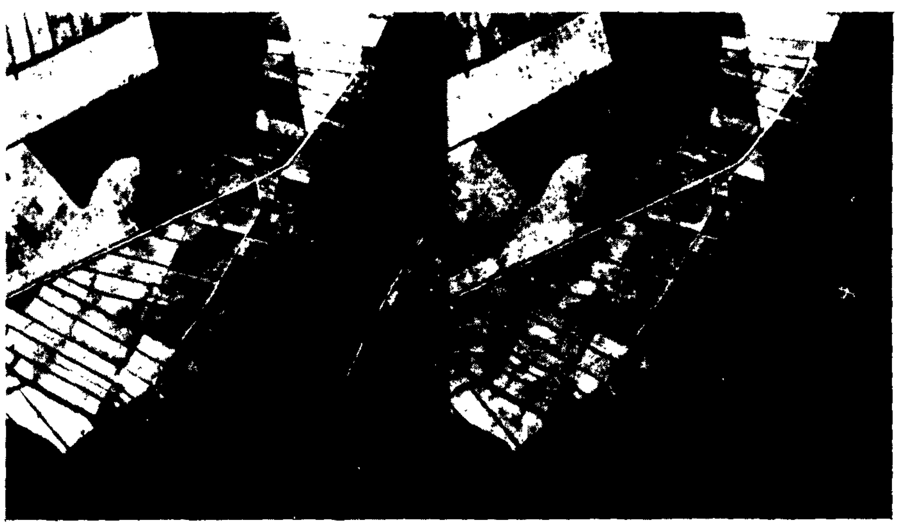


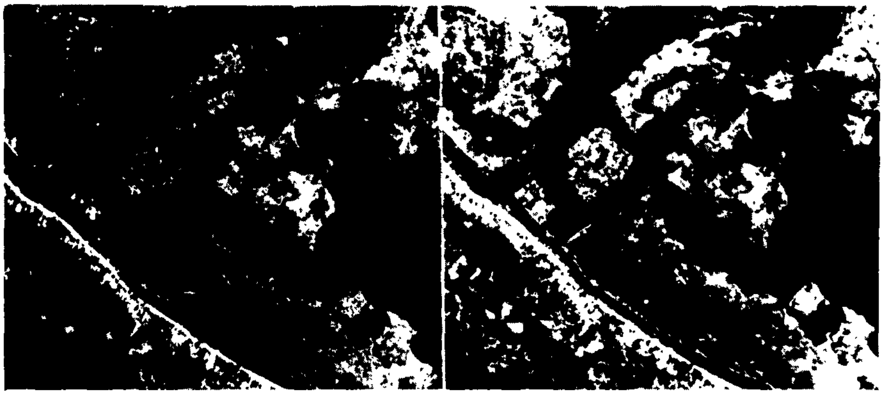
Fig. 29. Outwash surface, Portage County, Wisconsin (climate C-2)

a. Ridge and swale, Hinds County, Mississippi (climate D-2)

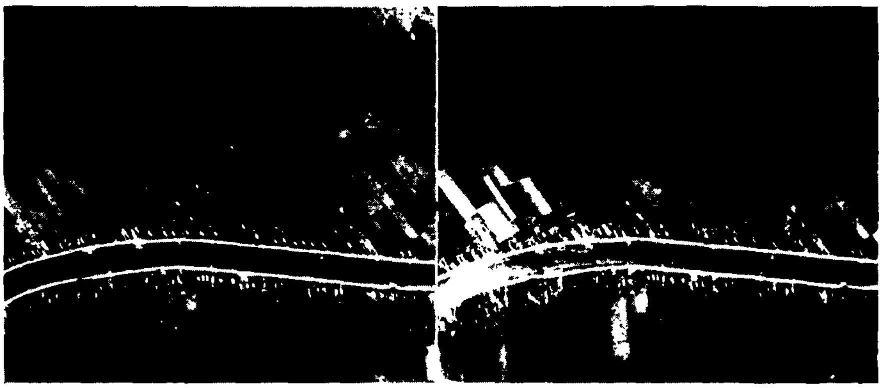


b. Natural levee, southern Louisiana (climate D-1)

Fig. 30. Floodplains



a. Natural levee and swamp, southern Louisiana
(climate D-2)



b. Natural levee and swamp, southern Louisiana
(climate D-2)

c. Deltaic plain, Walworth County, Wisconsin
(climate C-2)

Fig. 31. Deltaic surfaces

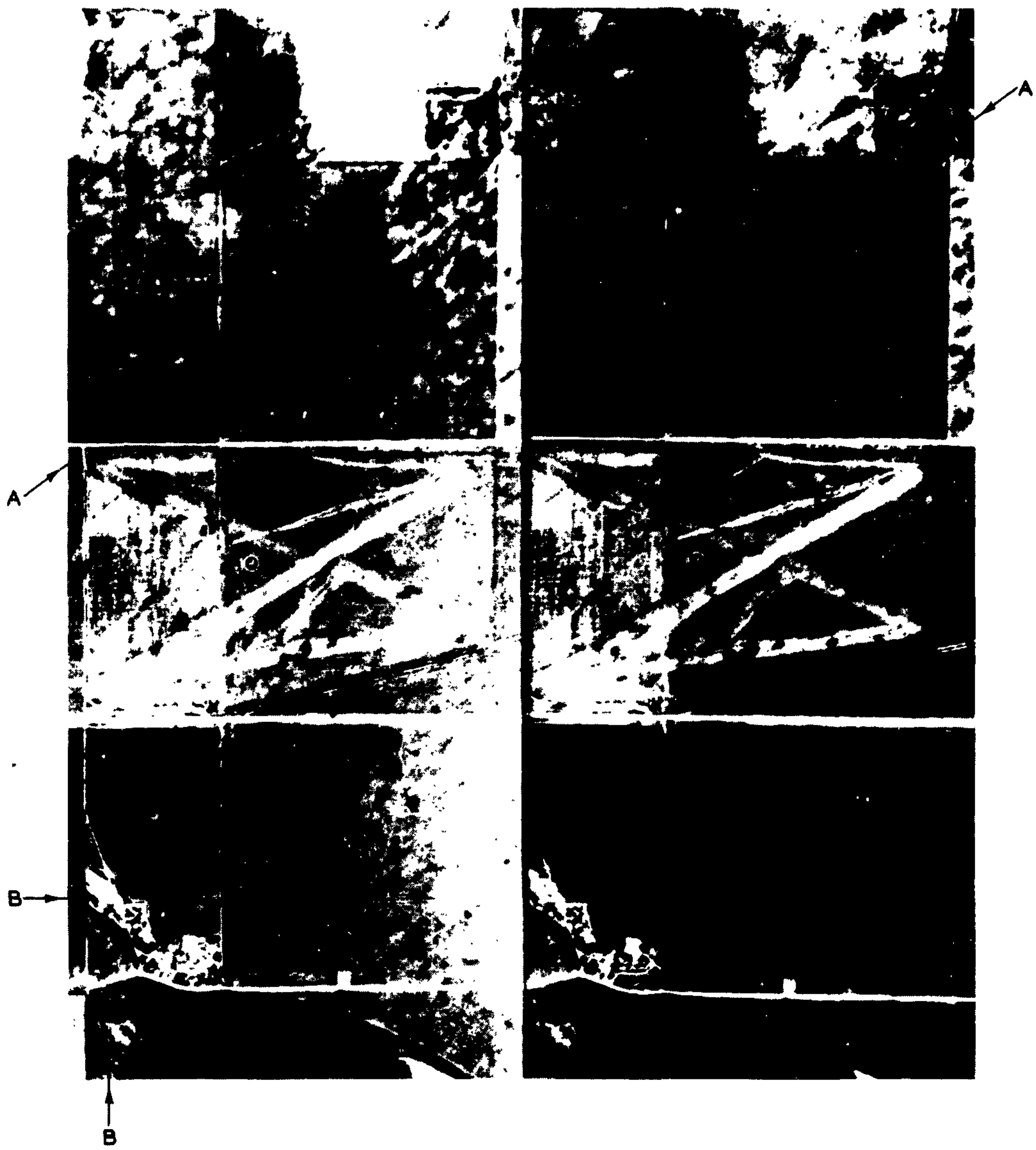


Fig. 32. Terrace, Burleigh County, North Dakota (climate C-3)

Fig. 33. Coastal alluvial plain, Pender County, North Carolina (climate D-2)

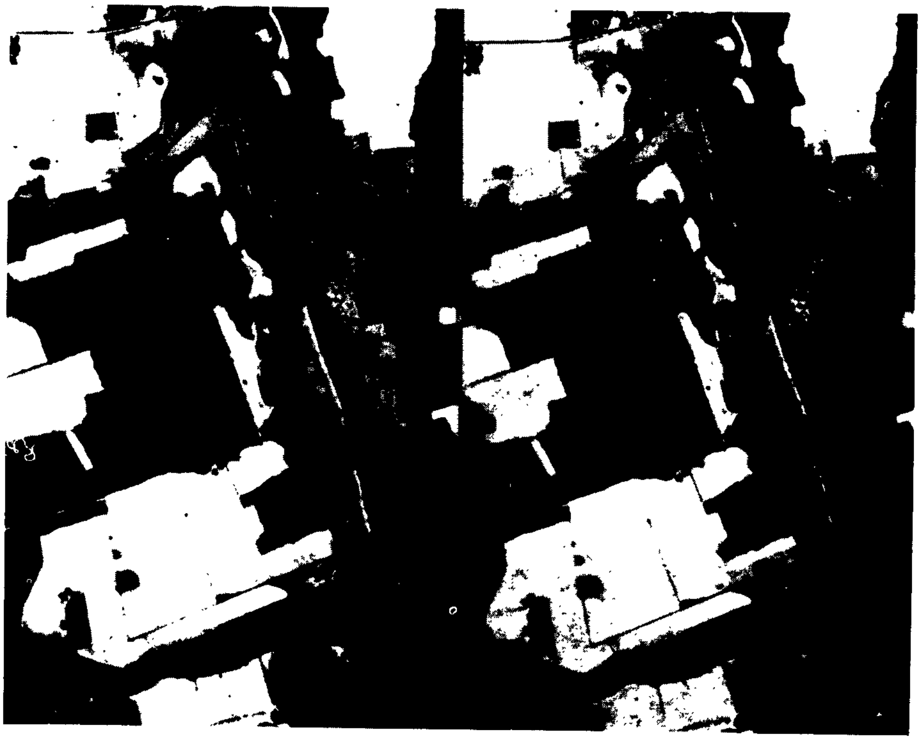
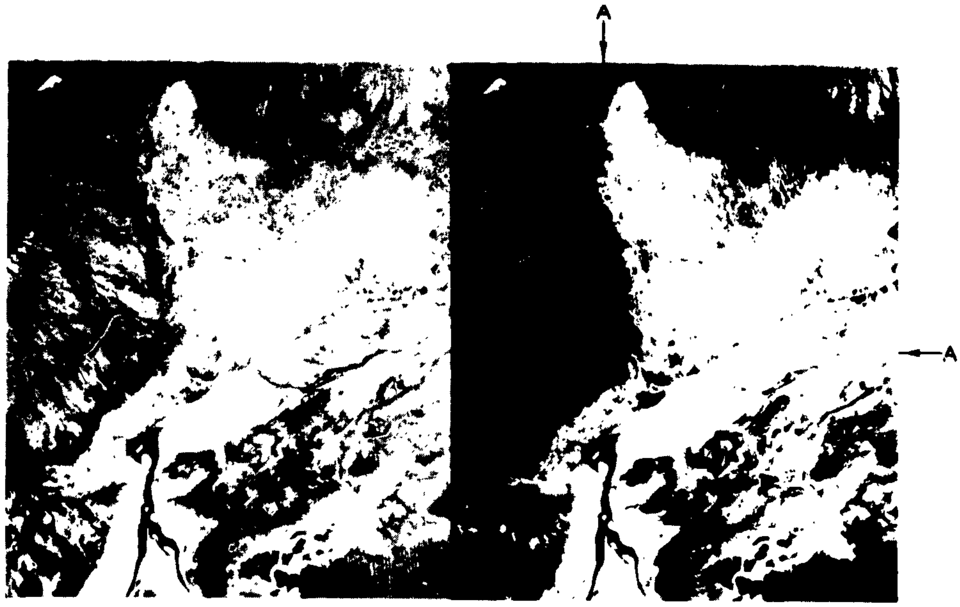


Fig. 34. Coastal alluvial plain, Wayne County, North Carolina (climate D-2)

Fig. 35. Bed of a perennial lake (lacustrine surface), Lucas County, Ohio (climate C-2)



a. Salina type

b. Dry type

Fig. 36. Examples of playa surfaces, Death Valley, California (climate D-4)

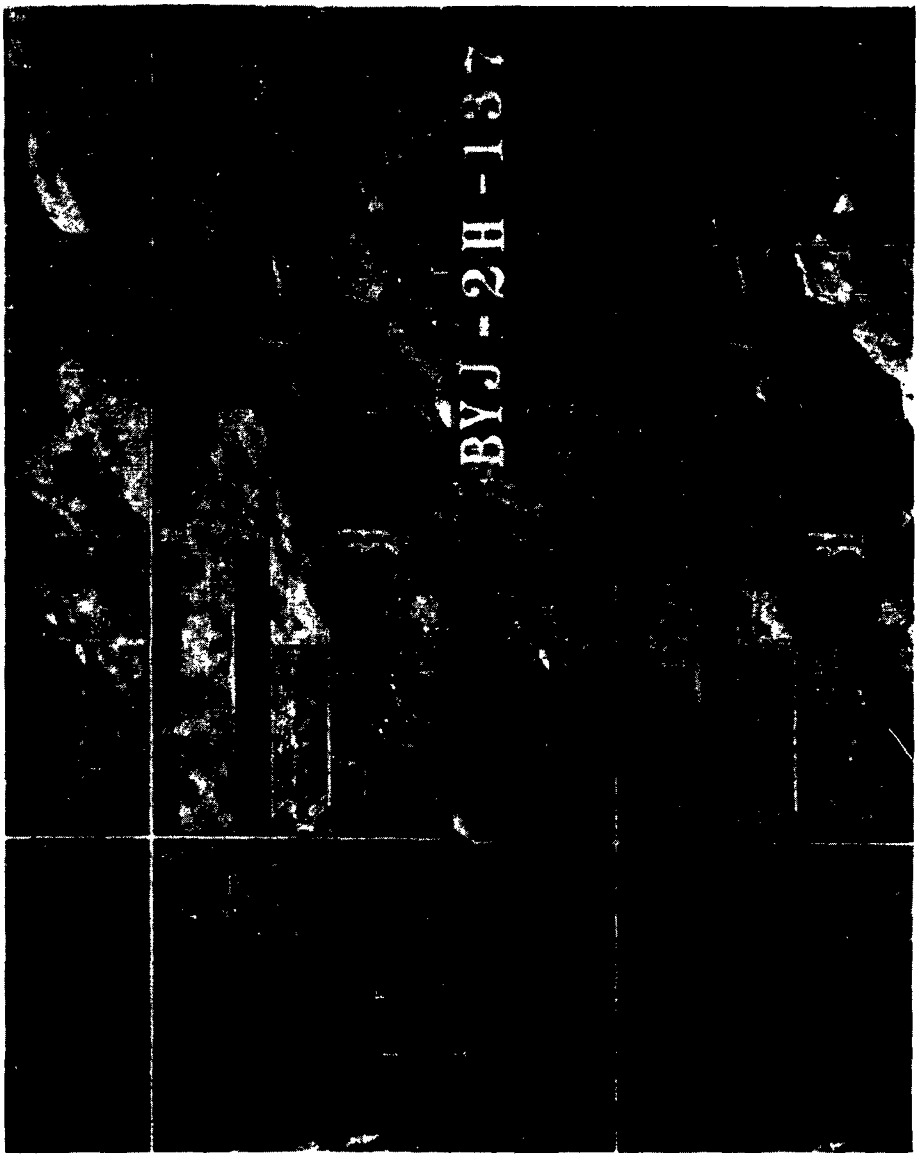


Fig. 37. Beach ridges, Wilkin County, Minnesota
(climate C-2)

Fig. 38. Pyroclastic cone, Jefferson County, Idaho
(climate D-2)

a. Lawrence County, Indiana (climate D-2)

b. Hart County, Kentucky (climate D-2)

Fig. 39. Limestone plains

Fig. 40. Shale plain, Yolo County, California (climate D-3)

Fig. 41. Sandstone plain, Brown County, Indiana
(climate D-2)

Fig. 42. Limestone-shale plain, Dearborn County, Indiana (climate D-2)

Fig. 43. Sandstone-shale plain, Pike County, Indiana (climate D-2)

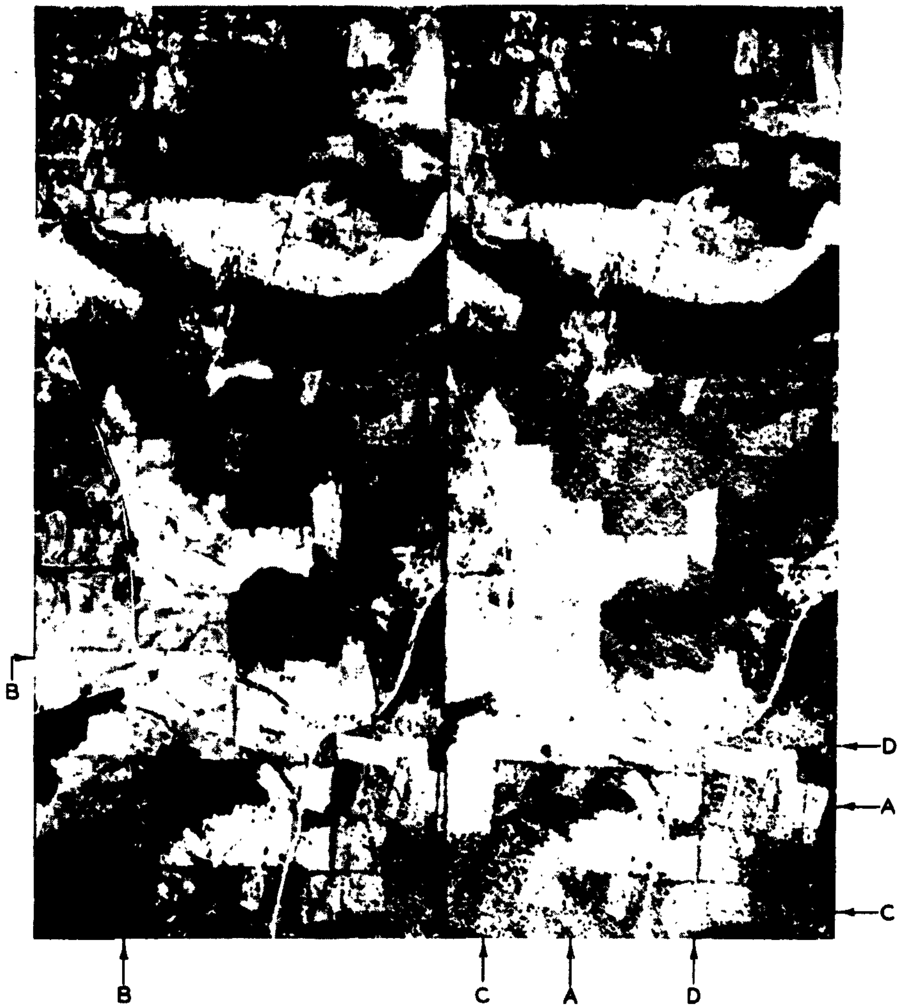


Fig. 44. Sandstone-shale-limestone plain, Martin County, Indiana (climate D-2)

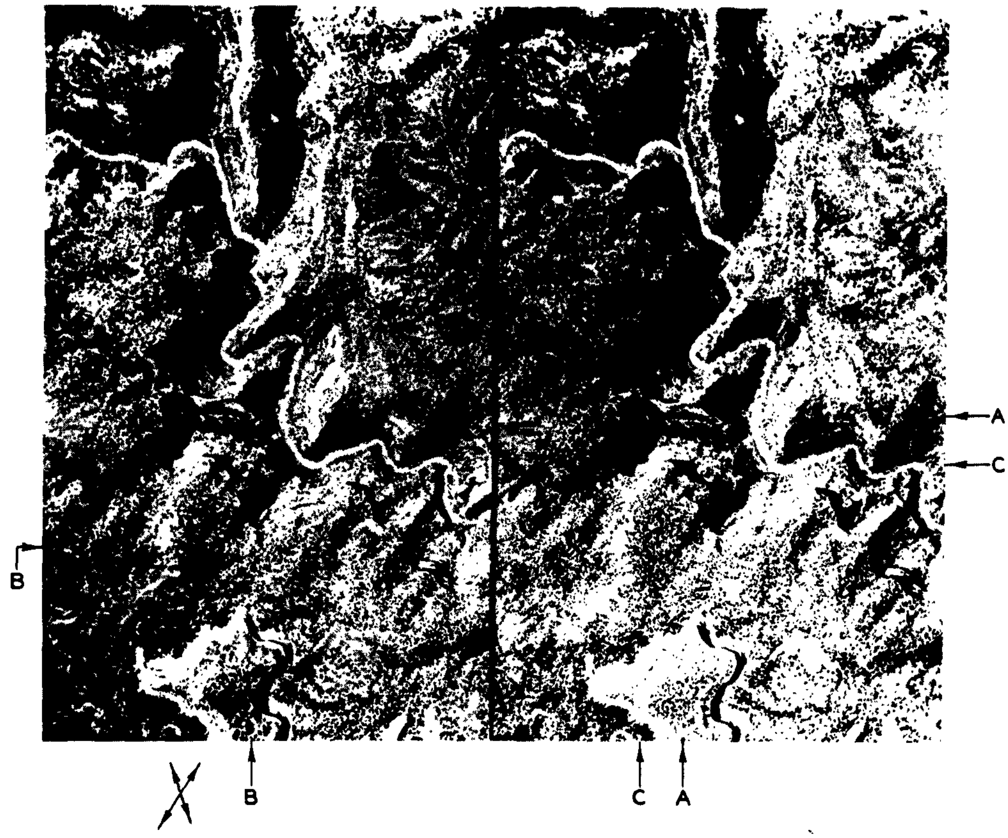


Fig. 45. Sandstone plateau, Mesa County, Colorado (climate C-3)

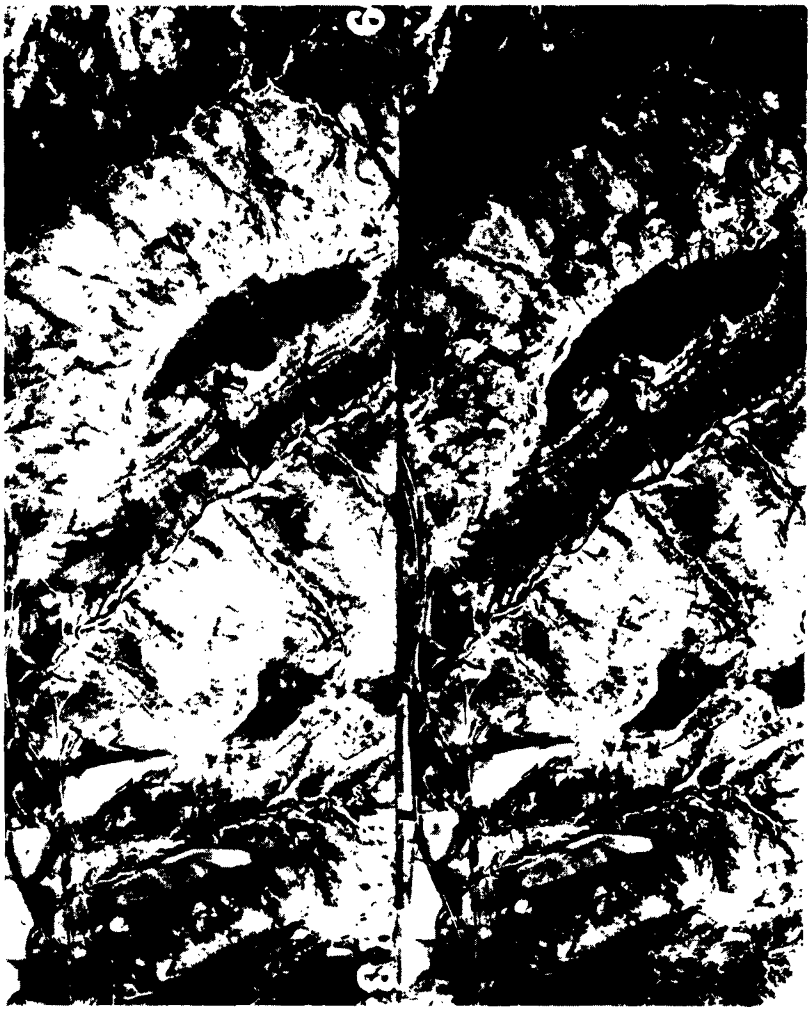


Fig. 46. Sandstone-shale plateau, Sheridan County, Wyoming (climate C-3)

Fig. 47. Limestone hills, Maury County, Tennessee (climate D-2)

Fig. 48. Shale hills, Berks County, Pennsylvania (climate D-2)

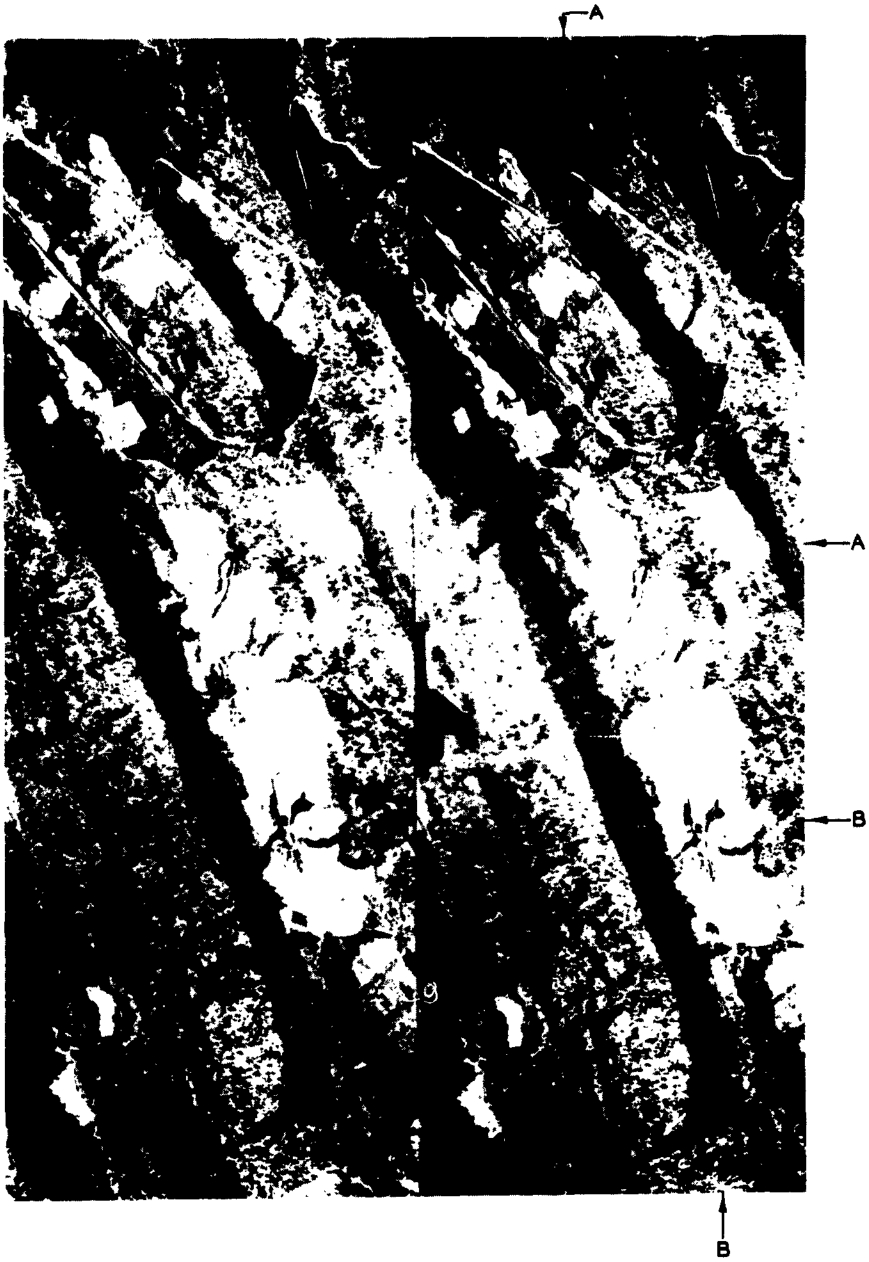


Fig. 49. Sandstone-shale hills, Jefferson County, Alabama (climate D-2)

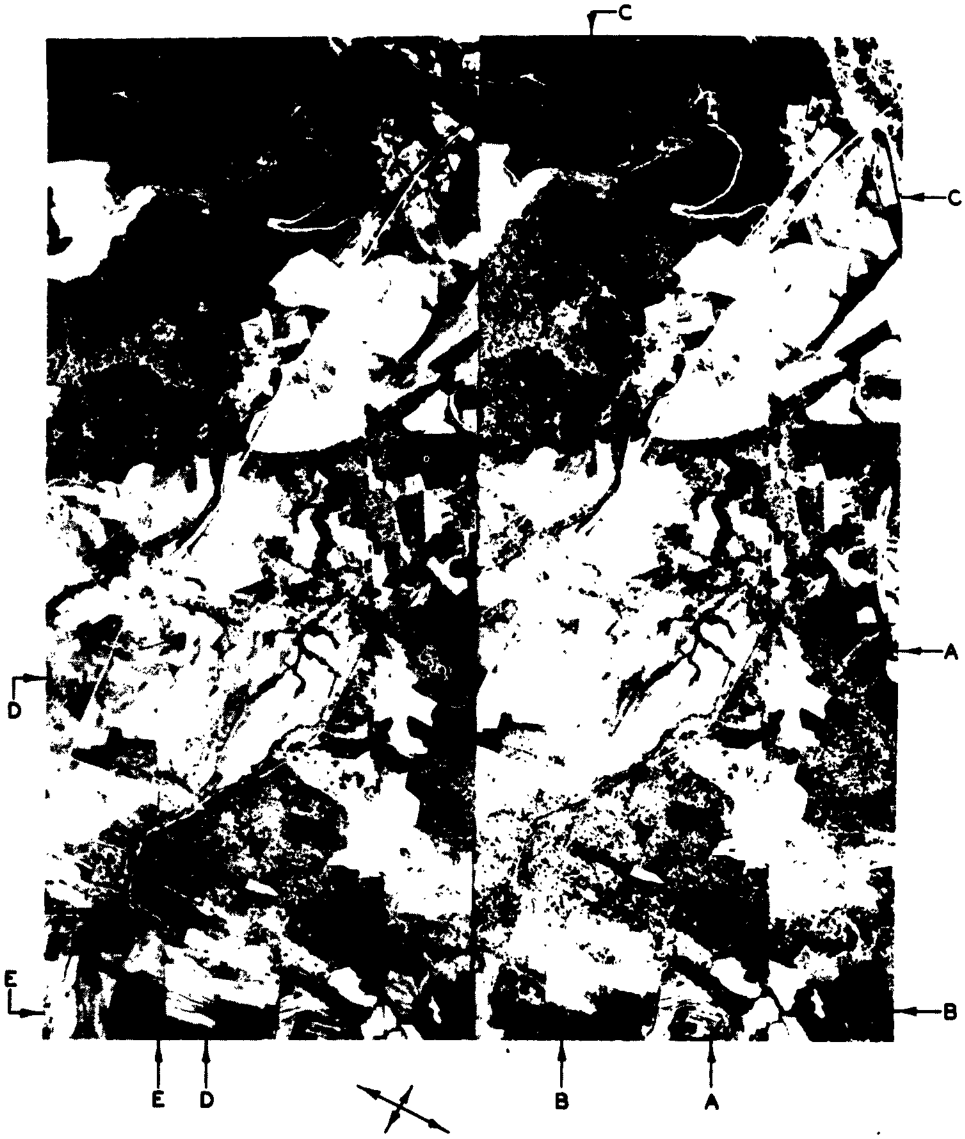


Fig. 50. Limestone-shale hills, Floyd County, Georgia (climate D-2)

Fig. 51. Basalt plain, Spokane, Washington (climate D-3)

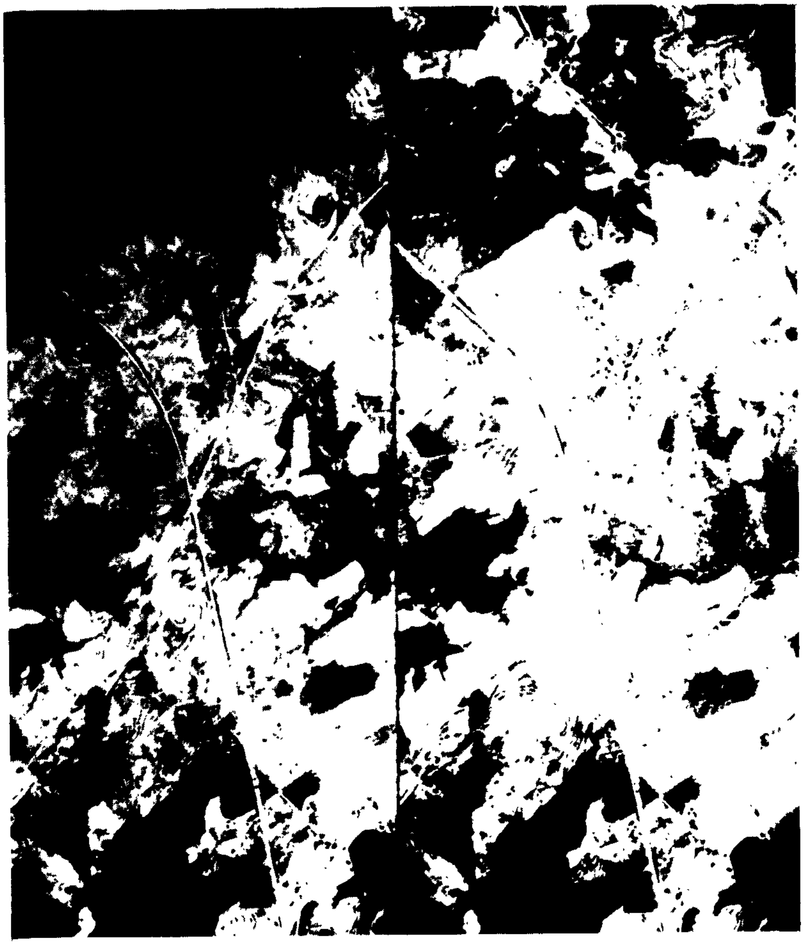


Fig. 52. Granite hills, DeKalb County, Georgia (climate D-2)

Fig. 53. Slate hills, Talladega County, Alabama
(climate D-2)

Fig. 54. Gneiss hills, York County, South Carolina (climate D-2)

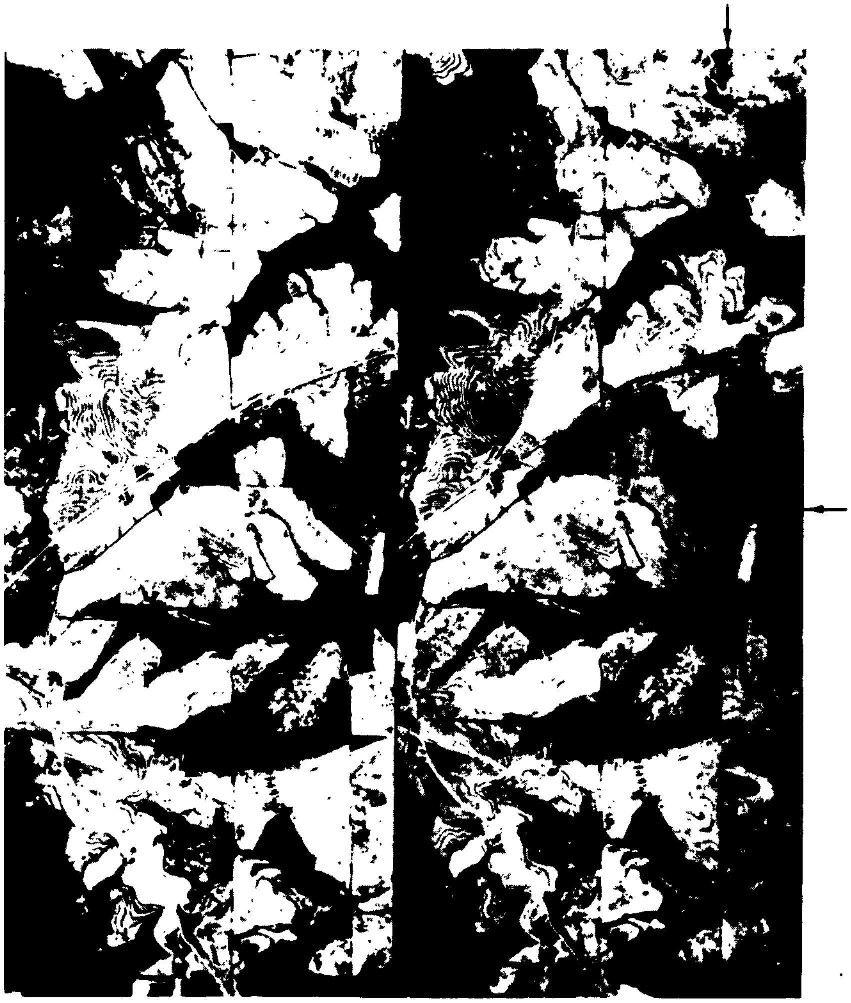


Fig. 55. Schist hills, Carroll County, Georgia
(climate D-2)

Fig. 56. Overlay of study area, Hart County, Kentucky (climate D-2) (in envelope attached to the inside of the back cover of Volume II)

Fig. 57. Photomosaic, Hart County, Kentucky, approximate scale 1:95,000

Fig. 58. Overlay of study area A, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

Fig. 59. Area A, Hart County, Kentucky, scale 1:20,000

Fig. 60. Overlay of study area B, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

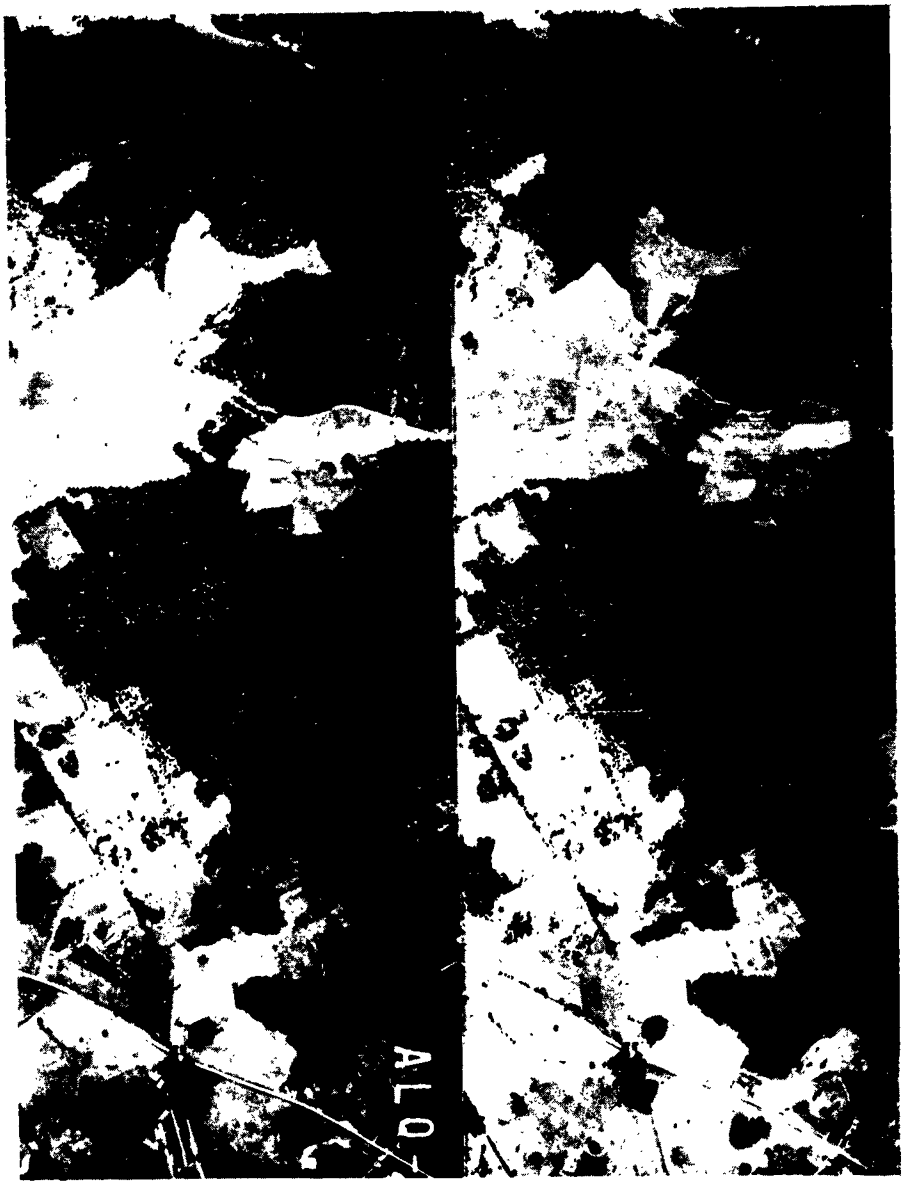


Fig. 61. Area B, Hart County,
Kentucky, scale 1:20,000

Fig. 62. Overlay of study area C, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

Fig. 63. Area C, Hart County, Kentucky, scale 1:20,000

Fig. 64. Overlay of study area A, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

Fig. 65. Overlay of study area B, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

Fig. 66. Overlay of study area C, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

Approximate scale, 1:95,000

For meaning of symbols, see table 12

Fig. 67. Overlay of terrain trafficability map, Hart County, Kentucky (in envelope attached to the inside of the back cover of Volume II)

APPENDIX A: INDEX TO GEOGRAPHIC LOCATION OF ALL TRAFFICABILITY TEST AREAS

1. Appendix A is an index of the soil test areas used in this study arranged alphabetically by states. Under each state the areas are designated by the nearest town and the county in which they were located, and are listed in the order in which the tests were conducted. Fig. A1 shows the approximate location. The number on the map corresponds to the area number given in the following tabulation.

Area No.	Town	County	Climate*
		Alabama	
1	Alaflora	Escambia	D-2
2	Oneonta	Blount	D-2
3	Wadley	Chambers	D-2
4	Leeds	Jefferson	D-2
5	Bessemer	Jefferson	D-2
6	Lincoln	Talladega	D-2
7	Talladega	Talladega	D-2
8	Sylacauga	Talladega	D-2
		Arkansas	
1	Little Rock	Pulaski	D-2
2	Newport	Jackson	D-2
		California	
1	Ogilby	Imperial	D-4
2	Tracy	San Joaquin	D-3
3	Los Banos	Merced	D-4
4	Corcoran	Kings	D-4
5	Mendota	Fresno	D-3, D-4
6	Soda Lake (Dry)	San Luis Obispo	D-2
7	Muroc (Edwards AFB)	Kern	D-4
8	McKittrick	Kern	D-4
9	Conner	Kern	D-4
10	Palmdale	Los Angeles	D-2
		Colorado	
1	Golden	Jefferson	C-3

(Continued)

* Climate code numbers are defined in Appendix B.

Area No.	Town	County	Climate
		Florida	
1	Chattahoochee	Gadson	D-2
2	Genoa	Hamilton	D-2
		Georgia	
1	Cussetta	Chattahoochee	D-2
2	Pecan City	Dougherty	D-2
3	Albany	Dougherty	D-2
4	Colon	Clinch	D-2
5	Roopville	Carroll	D-2
6	Stone Mountain	DeKalb	D-2
7	Crystal Springs	Floyd	D-2
8	Shannon	Floyd	D-2
9	Silvertown	Upson	D-2
		Idaho	
1	Burley	Cassia	C-3
2	Twin Falls	Twin Falls	C-4
3	St. Anthony	Fremont	C-3
4	Roberts	Jefferson	C-3
		Illinois	
1	Sheldon	Iroquois	C-2
2	Champaign	Champaign	D-2
3	Galena	Jo Daviess	C-2
4	Galena	Jo Daviess	C-2
5	Galena	Jo Daviess	C-2
		Indiana	
1	Johnson	Gibson	D-2
2	Michigantown	Clinton	D-2
3	Evansville	Vanderburg	D-2
4	Medaryville	Pulaski	C-2
5	Perth	Clay	D-2
6	Marco	Greene	D-2
7	Thayer	Newton	C-2
8	Fort Wayne	Allen	C-2
9	Lafayette	Tippecanoe	D-2
10	New Harmony	Posey	D-2
11	Evansville	Vanderburg	D-2
12	Patoka	Gibson	D-2
13	West Lafayette	Tippecanoe	D-2
14	Buckskin	Gibson	D-2

(Continued)

Area No.	Town	County	Climate
	Indiana (Continued)		
15	Stringtown	Vanderburg	D-2
16	Washington	Daviess	D-2
17	Dunes State Park	Porter	C-2
18	Nashville	Brown	D-2
19	Aurora-Guilford	Dearborn	D-2
20	Celestine	Dubois	D-2
21	Mitchell	Lawrence	D-2
22	Shoals	Martin	D-2
23	Bloomington	Monroe	D-2
24	Stendal	Pike	D-2
	Iowa		
1	Mason City	Cerro Gordo	C-2
2	Waterloo	Blackhawk	C-2
3	Des Moines	Polk	C-2
4	Council Bluffs	Pottawattamie	C-2
5	Sioux City	Woodbury	C-2
	Kansas		
1	Wathena	Doniphan	C-2, D-2
2	McAllister	Logan	D-3
3	Olathe	Johnson	D-2
	Kentucky		
1	West Point	Hardin	D-2
2	Garrett	Meade	D-2
3	Morganfield	Union	D-2
	Louisiana		
1	Mound	Madison	D-2
2	Monroe	Ouachita	D-2
3	Lafayette	Lafayette	D-2
	Maryland		
1	Gaithersburg	Montgomery	D-2
2	Collington	Prince Georges	D-2
3	Easton	Talbot	D-2
4	Easton	Talbot	D-2

(Continued)

Area No.	Town	County	Climate
		Michigan	
1	Coldwater	Branch	C-2
2	Roscommon	Roscommon	C-2
3	Grayling	Crawford	C-2
4	Frederic	Crawford	C-2
5	Manistee	Manistee	C-2
6	Hastings	Barry	C-2
7	Houghton Lake	Roscommon	C-2
8	Petoskey	Emmet	C-2
9	Mason	Ingham	C-2
		Minnesota	
1	Bemidji	Beltrami	C-2
2	Waskish	Beltrami	C-2
3	Strawberry Lake	Becker	C-2
4	Zimmerman	Sherburne	C-2
5	Minneapolis	Dekota	C-2
6	Ogema	Becker	C-2
7	Detroit Lakes	Becker	C-2
8	Breckenridge	Wilkin	C-2
		Mississippi	
1	Cleveland	Bolivar	D-2
2	Elizabeth	Washington	D-2
3	Vicksburg	Warren	D-2
4	Hebron	Jones	D-2
5	Hollandale	Washington	D-2
6	Shaw	Bolivar	D-2
7	Ellisville	Jones	D-2
		Missouri	
1	Essex	Stoddard	D-2
2	Sikeston	Scott	D-2
3	Charleston	Mississippi	D-2
4	Charleston	Mississippi	D-2
5	Marshall	Saline	D-2
6	Tarkio	Atchison	C-2
7	Springfield	Greene	D-2
		Nebraska	
1	Kearney	Buffalo	C-2
2	Minden	Kearney	C-2
3	North Platte	Lincoln	C-2

(Continued)

Area No.	Town	County	Climate
	Nebraska (Continued)		
4	North Platte	Lincoln	C-2
5	Norfolk	Madison	C-2
	Nevada		
1	Winnemucca Lake (Dry)	Washoe	D-4
2	Gerlack	Washoe	D-4
3	Fernley	Lyon	D-4
	New York		
1	Elba	Genessee	C-2
	North Carolina		
1	Asheboro	Randolph	D-2
2	Goldsboro	Wayne	D-2
3	Wilmington	Pender	D-2
4	Elizabeth City	Pasquotank	D-2
	North Dakota		
1	--	Benson and Nelson	C-3
2	Michigan	Nelson	C-3
3	Minot	Ward	C-3
4	Grand Forks	Grand Forks	C-2
5	Grand Forks	Grand Forks	C-2
6	Fargo	Cass	C-2
7	Bismarck	Burleigh	C-3
8	Bismarck	Burleigh	C-3
9	Bismarck	Burleigh	C-3
10	Minot	Ward	C-3
11	Sanborn	Barnes	C-3
12	Michigan	Nelson	C-3
13	Leeds	Benson	C-3
14	Minot	Ward	C-3
	Ohio		
1	Johnstown	Licking	D-2
2	Delta	Fulton	C-2
3	Alton	Franklin	D-2
4	--	Fulton and Lucas	C-2
5	Tipp City	Miami	D-2
6	Gahanna	Franklin	D-2
7	Zanesville	Muskingum	D-2

(Continued)

Area No.	Town	County	Climate
	Ohio (Continued)		
8	Bono	Lucas	C-2
9	Richfield Center	Lucas	C-2
10	Monclova	Lucas	C-2
	Oregon		
1	Pendleton	Umatilla	C-3, D-3
2	Umatilla	Umatilla	D-3, D-4
3	North Bend	Coos	D-1
4	Fort Klamath	Klamath	D-3
5	Harper	Malheur	C-3
6	Dallas	Polk	D-2
	Pennsylvania		
1	Shoemakersville	Berks	D-2
2	Waynesburg	Greene	D-2
3	Kittanning	Armstrong	C-2
	South Carolina		
1	Belton	Anderson	D-2
2	Filbert	York	D-2
3	Conway	Horry	D-2
4	Lake City	Florence	D-2
5	Columbia	Richland	D-2
6	McColl	Marlboro	D-2
	South Dakota		
1	Aberdeen	Brown	C-2
2	Aberdeen	Brown	C-2
	Tennessee		
1	Lawrenceburg	Lawrence	D-2
2	Columbia	Maury	D-2
3	White House	Robertson	D-2
	Utah		
1	Wendover	Tooele	C-4
2	Brigham	Box Elder	C-3

(Continued)

Area No.	Town	County	Climate
		Virginia	
1	Waynesboro	Augusta	D-2
2	Danville	Pittsylvania	D-2
3	Suffolk	Nansemond	D-2
4	Fairfax	Fairfax	D-2
5	Amelia	Amelia	D-2
		Washington	
1	Pullman	Whitman	D-2, D-3
2	Ritzville	Adams	D-3
3	Moses Lake	Grant	C-4
4	Medical Lake	Spokane	D-3
		West Virginia	
1	Inwood	Berkeley	D-2
		Wisconsin	
1	Janesville	Rock	C-2
2	Redgranite	Waushara	C-2
3	Plover	Portage	C-2
4	Glenbeulah	Sheboygan	C-2
5	New Richmond	St. Croix	C-2
6	Marshall	Dane	C-2
		Wyoming	
1	Lovell	Big Horn	C-3
2	Veross	Sheridan	C-3

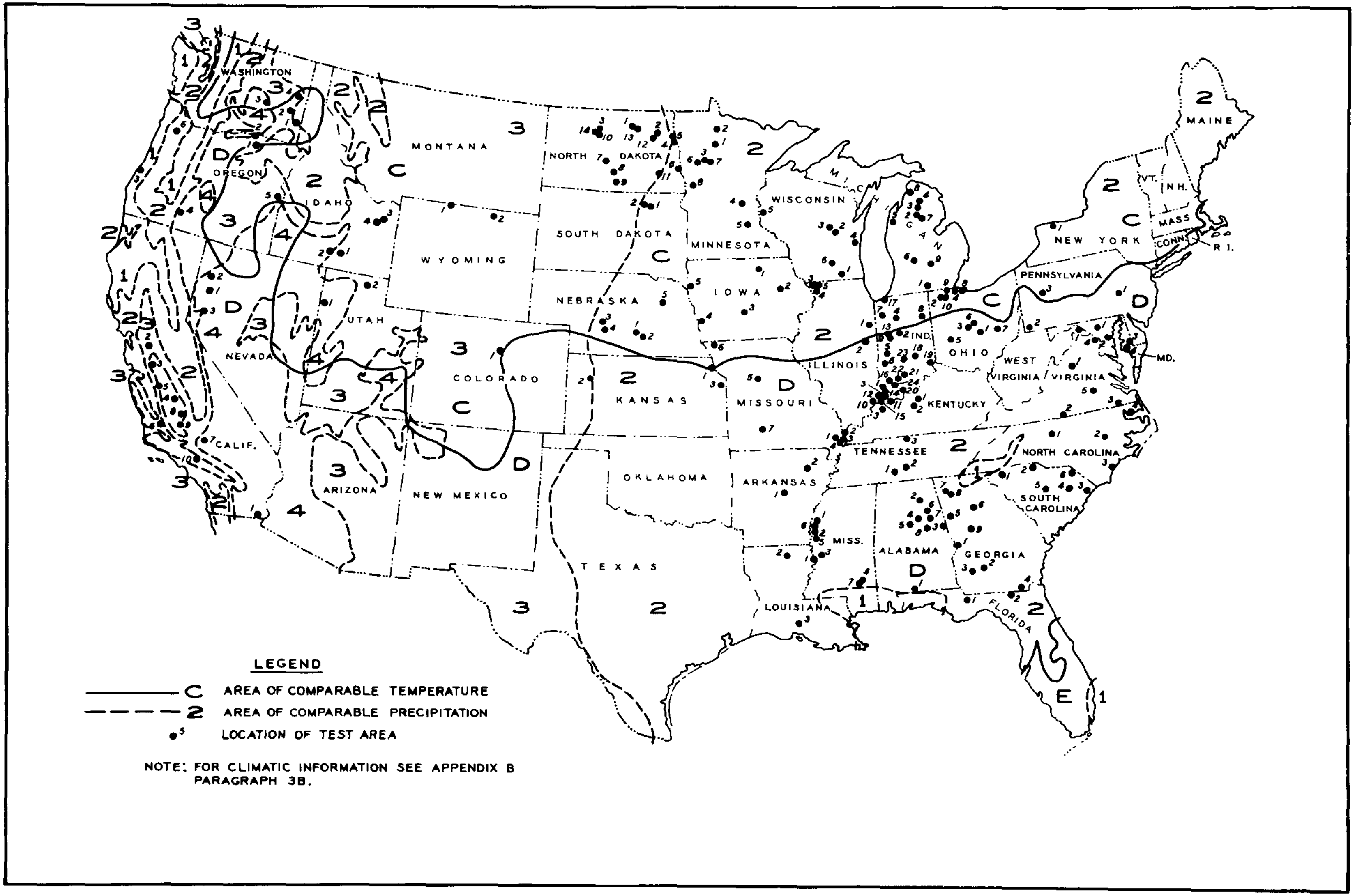


Fig. A1. Locations of test areas

APPENDIX B: SUMMARY OF SOIL AND SITE DATA

1. Appendix B contains a summary tabulation of the soil and site data collected from the 550 sites tested. The soil data for fine-grained soils are average values for the 6- to 12-in. layer, and soil data for clean sands (SP) are average values for the 0- to 6-in. layer. The tabulation is divided into two parts based upon the classification of landscape types formed chiefly of unconsolidated or consolidated materials. The next order of subdivision for the unconsolidated and consolidated materials is based upon method of deposition and rock type, respectively.

2. Some of the soil strength data collected for this report were collected prior to the development of the remolding test. In order to convert the cone index readings to rating cone index an average remolding index was used for that specific soil type and topographic position. The average remolding index was obtained from TM No. 3-240, 16th Supplement, which presents ranges and means determined from over 1100 sets of data of all pertinent soil property data for each soil type for several topographic positions and wetness conditions.

3. Definitions of column headings and symbols used in the tabulation are as follows:

   a. The side headings of the various sections are the names of the landscape types described in Parts V and VI of main text. The page number in parentheses denotes the page on which the detailed description begins.

   b. Column headings are as follows:

      (1) Climate. The climatic regime of each landscape type is described in general terms according to the following code:

Temperature		Precipitation
A. Very cold	Tundra	1. >60 in., very humid
B. Cold		2. 20-60 in., humid
	5000 degree-days	
C. Cool		3. 10-20 in., transitional
	250 degree-days (24-in. frost depth)	
D. Warm		4. <10 in., arid
	Nonfrost	
E. Hot		

See fig. A1 in Appendix A for generalized boundaries of these regions.

(2) Site. The generalized physiographic position of the samples employed to determine numerical data is designated:

H. Crest or side slope of uplands

L. Valley or depression floor

(3) STC. Soil trafficability class, as per table 3 of the main text.

(4) USCS. Soil group according to the Unified Soil Classification System. See table 1, main text.

(5) USDA. Soil texture according to the United States Department of Agriculture system. See fig. 1, main text.

(6) RCI (Min). The minimum rating cone index exhibited by the soil. Numbers without parentheses are measured values; numbers in parentheses are estimated values.

(7) RCI (Mean). The mean rating cone index of all samples of the soil type. Both measured and estimated values were employed, and where the majority of the data used in determining averages was estimated, these averages are given in parentheses.

(8) N. The number of samples available in each soil type.

(9) VC. The vehicle category having the highest RCI requirements that can traverse the soil. Vehicle category is evaluated on the basis of RCI (Min). See tabulation on page 13 of main report.

Landscapes in Unconsolidated Materials

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
				Eolian				
Dune fields (page 59)								
C-2	H	A	SP	S	38	(97)	5	---
	H	D	SP-SM	S	---	(242)	1	7
	L	A	SP	S	108	(135)	3	---
	L	D	SM	LS	55	138	2	7
C-3	H	A	SP	S	---	(96)	1	---
	H	D	SP-SM	S	---	300+	1	7
	H	D	SM	SL	---	300+	1	7
C-4	H	D	SP-SM	S	---	235	1	7
	L	D	ML	SiL	---	300+	1	7
D-1	H	A	SP	S	76	(94)	2	---
	L	A	SP	S	---	(75)	1	---
	L	D	SP-SM	S	---	300+	1	7

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-4	H	A	SP	S	16	(59)	3	---
	H	D	SM	SL	---	(224)	1	6
	L	A	SP	S	---	(233)	1	---
	L	D	SM	SL	---	300+	1	7
							26	
Loess surfaces (page 64)								
C-2	H	B	CH	SiC	---	(205)	1	7
	H	C	CL	SiL	132	180	4	7
	H	D	ML	SiL	---	(128)	1	7
				Si	94	127	2	7
	L	C	CL	SiL	89	118	2	7
	L	D	ML	SiL	---	261	1	7
	L	D	OL	SiL	---	73	1	5
	L	D	OH	SiL	---	(76)	1	5
C-3	H	D	ML	Si	---	(141)	1	7
	L	C	GM	--	---	(146)	1	7
C-4	H	C	CL	Si	---	300+	1	7
	H	D	ML	SiL	---	(200)	1	7
	L	C	CL	Si	---	(182)	1	7
D-2	H	C	CL	SiL	71	102	4	7
				Si	---	(116)	1	7
	H	D	ML	Si	---	(175)	1	7
	L	C	CL	SiL	(80)	(122)	4	7
	L	D	ML	SiL	---	145	1	7
				Si	---	(113)	1	7
	L	D	OH	--	---	50	1	3
D-3	H	C	CL	SiL	---	(179)	1	7
	H	D	ML	SiL	---	(209)	1	7
				Si	186	186	1	7
	L	D	ML	SiL	---	300+	1	7
				Si	---	300+	1	7
	L	D	CL-ML	SiL	---	300+	1	7
	L	D	OL	Si	---	49	1	2
D-4	H	D	ML	Si	---	214+	2	7
							40	

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
				Glacial				
Old ground moraines (Illinoian stage) (page 69)								
D-2	H	C	CL	SiL	(92)	(100)	2	7
	L	D	ML	SiL	(87)	(92)	2	6
	L	D	OL	SiL	---	(60)	1	4
							5	
Young ground moraines (Wisconsin stage) (page 72)								
C-2	H	D	OH	L	---	(82)	1	6
	H	D	ML	SiL	---	(90)	1	6
	L	D	OH	SiL	---	(47)	1	2
	L	D	OL	SL	(64)	(88)	2	4
	L	E	Pt	--	---	(52)	1	3
C-3	H	C	CL	L	---	(149)	1	7
				C	---	(129)	1	7
				SL	(81)	(114)	3	7
	H	D	ML	SL	---	(128)	1	7
	H	D	OL	SL	---	(115)	1	7
	H	B	CH	SiL	---	(102)	1	7
	L	C	CL	L	---	(34)	1	2
	L	D	OH	C	46	(59)	3	3
				L	(58)	(60)	2	4
D-2	H	B	CH	CL	---	(66)	1	4
				SiL	---	(123)	1	7
	H	C	CL	L	(93)	(100)	1	7
				SiL	(73)	(106)	7	7
	H	D	ML	SiL	(88)	(108)	4	7
	L	B	CH	SiL	(86)	(87)	2	6
	L	C	CL	SiL	---	(55)	1	3
	L	D	ML	SL	(58)	(63)	2	4
				SiL	---	(79)	1	5
	L	D	OL	SiL	(45)	(60)	4	7
	L	D	OH	L	---	(72)	1	5
				SiL	(30)	(55)	6	3
							51	

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
Ridge moraines (page 75)								
Michigan, Minnesota, and Wisconsin								
C-2	H	A	SP	S	---	156	1	---
	H	C	CL	C	---	(162)	1	7
	H	C	SC	SL	---	(236)	1	7
	H	D	SM	S	---	300+	1	7
				SL	(135)	(174)	2	7
	H	D	SP-SM	S	(124)	(228)	6	7
	H	D	SM-SC	SL	62	73	2	5
	L	A	SP	S	---	45	1	---
	L	C	SC	SL	---	(252)	1	7
	L	D	ML	L	---	(127)	1	7
				SiL	---	(45)	1	2
	L	D	SM	SL	(144)	(156)	3	7
				LS	32	125+	3	7
	L	D	OH	SiL	---	(69)	1	4
	L	D	SP-SM	S	(188)	(237+)	3	7
	L	D	SM-SC	SL	---	(108)	1	7
Indiana								
C-2	H	C	CL	SiCL	---	(228)	1	7
				SiL	(140)	(142)	2	7
	L	B	CH	L	---	(173)	1	7
	L	C	CL	SL	---	(159)	1	7
				SiL	(127)	(156)	2	7
				C	---	(141)	1	7
							37	
Kettle-kame moraines (page 79)								
C-2	H	D	SM	LS	---	25	1	1
				S	283	290+	2	7
	H	D	MH	SiL	---	(155)	1	7
	L	C	CL	L	---	(179)	1	7
				SiL	---	(59)	1	3
	L	D	OL	SiL	(23)	(33)	2	2
	L	D	OH	L	(53)	(54)	2	3
	L	E	Pt	--	---	(27)	1	1
C-3	H	C	CL	L	(131)	(135)	2	7
	H	D	SM-SC	SL	---	(184)	1	7
	L	D	OH	L	18	(78)	3	5
							17	

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
Drumlin fields (page 84)								
C-2	H	C	CL	CL	---	(129)	1	7
	H	D	SM	LS	---	300+	1	7
	L	B	CH	SiC	---	(196)	1	7
	L	D	MH	SiL	---	(104)	1	7
	L	E	Pt	--	(64)	(72)	2	5
							6	
Eskers and kames (page 86)								
C-2	H	D	SP-SM	S	---	300+	1	7
							1	
Fluvial								
Alluvial fans and aprons (irrigated)(page 88)								
D-2	L	D	ML	SiL	---	256	1	7
D-3	L	C	CL	SiL	---	81	1	6
D-4	L	C	CL	SL	---	60	1	4
							3	
Alluvial fans and aprons (unirrigated)(page 88)								
D-2	L	B	CH	C	---	85	1	6
	L	D	ML	SiL	---	178	1	7
	L	D	SM	LS	---	300+	1	7
D-3	H	D	SM-SC	SL	---	94	1	6
	L	C	CL	SiC	---	38	1	2
				SiL	---	51	1	3
D-4	L	C	CL	SL	---	223	1	7
				L	(90)	(94)	2	6
				SiL	---	14	1	1
	L	C	SC	SL	---	66	1	4
	L	D	SM	SL	124	231	3	7
				LS	---	300+	1	7
				S	---	254	1	7
	L	D	SM-SC	SL	---	215	1	7
							17	

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
Outwash surfaces (page 93)								
C-2	H	C	SC	SL	---	(250)	1	7
	H	C	CL	SiL	---	(133)	1	7
	H	D	SP-SM	S	---	(118)	1	7
	L	D	SM	SiL	---	(174)	1	7
	L	D	ML	SiL	---	(114)	1	7
	L	D	OH	SiL	---	(91)	1	6
	L	E	Pt	--	---	(11)	1	1
							7	
Floodplains (page 96)								
D-2	H	C	CL	C	---	(131)	1	7
				SiL	(61)	(100)	4	6
	H	D	ML	Si	---	(128)	1	7
				SiL	(128)	(144)	3	7
	H	D	CL-ML	SL	---	(95)	1	6
	H	D	MH	SiL	(84)	(100)	2	7
	L	B	CH	C	(85)	(119)	3	7
	L	C	CL	SL	---	(72)	1	5
				SiL	(52)	(86)	9	6
	L	D	ML	SiL	(55)	(58)	2	3
				Si	(34)	(61)	4	4
	L	D	MH	SiL	---	(45)	1	2
	L	D	OL	SiL	---	(116)	1	7
	L	D	OH	SiL	(41)	(50)	2	3
D-4	L	B	CH	C	---	106	1	7
	L	D	OH	CL	---	47	1	2
							37	
Deltaic surfaces (page 103)								
C-3	L	D	SM	SL	---	70	1	1
	L	D	OL	L	---	36	1	2
D-2	H	A	SP	S	---	(126)	1	---
	L	C	CL	SiL	---	(54)	1	3
							4	
Terraces (page 107)								
C-2	L	D	OL	SiL	---	(76)	1	5

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-3	H	D	SM	SL	---	(212)	1	7
	L	B	CH	L	---	(90)	1	6
	L	D	SM	SL	(111)	(111)	2	7
D-2	H	A	SW	S	---	(300+)	1	7
	H	C	SC	SL	---	(142)	1	7
				SiL	---	(166)	1	7
	H	C	CL	SL	(62)	(114)	2	7
				L	(145)	(184)	2	7
	H	D	SM	SL	(212)	(219)	2	7
	H	D	MH	SiL	---	(74)	1	5
	H	D	OL	L	---	(130)	1	7
	H	D	OH	L	(79)	(80)	3	6
	L	B	CH	C	(83)	(96)	2	6
	L	C	CL	L	---	(67)	1	4
				SiL	(25)	(48)	3	2
	L	C	CL	SiL	67	(72)	2	6
	L	D	SM	SL	111	(114)	2	7
	L	D	ML	C	---	(51)	1	3
				SiL	(56)	(74)	2	5
	L	D	MH	SiL	---	(75)	1	5
	L	D	OH	SL	(54)	(56)	2	3
				L	(18)	(50)	10	2
E-2	H	C	CL	SiL	---	(131)	1	7
	H	D	SM	SL	---	(237)	1	7
							47	

Coastal alluvial plains (page 110)

Coastal swamps

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	L	D	OH	L	---	(60)	1	4
	L	D	SM-SC	SL	---	71	1	5
	L	E	Pt	--	---	(67)	1	4
							3	

Marine terraces and undifferentiated surfaces

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	A	SP	S	(105)	(157)	5	---
	H	A	SW-SM	SL	---	(188)	1	7
	H	C	CL	SiL	126	(140)	2	7
	H	C	SC	LS	(140)	(172)	4	7
	H	D	ML	SiL	(19)	(66)	3	4
	H	D	ML-CL	SiL	---	300+	1	7

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	D	SM	SL	(139)	(208)	5	7
	H	D	SP-SM	S	---	(300+)	1	7
	L	A	SP	S	(45)	(75)	4	--
	L	C	CL	SiL	(44)	(84)	9	6
	L	C	SC	LS	(81)	(109)	3	7
	L	D	ML	SiL	(43)	(66)	4	4
				L	(49)	(69)	2	4
	L	D	CL-ML	SiL	(42)	68	2	4
	L	D	SM	SL	(33)	(130)	6	7
	L	D	MH	SiL	---	(94)	1	6
							53	

Lacustrine

Beds of perennial lakes
(lacustrine surfaces)(page 116)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-2	H	B	CH	C	---	(119)	1	7
	H	C	CL	L	---	(127)	1	7
				SiL	(82)	(128)	9	7
	H	C	SC	LS	---	(141)	1	7
	H	D	SM	SL	---	(212)	1	7
				LS	(178)	(195)	2	7
	H	D	SP-SM	S	(245)	(250)	2	7
	H	D	OL	SiL	(169)	(182)	2	7
	H	D	OH	L	---	(68)	1	4
				SiL	(114)	(128)	2	7
	H	B	CH	L	---	(118)	1	7
				C	---	(150)	1	7
				SiL	(102)	(130)	4	7
				SiCL	---	(126)	1	7
	H	C	CL	SiL	(64)	(104)	5	7
	H	C	SC	SL	(122)	(132)	2	7
	H	D	ML	SiL	(23)	(36)	3	2
				SL	---	(37)	1	2
	H	D	ML-MH	SiL	---	(54)	1	3
	H	D	SM	LS	(44)	(67)	3	4
	L	D	SP-SM	S	---	(185)	1	7
	L	D	OL	SL	(87)	(99)	2	6
				L	(89)	(96)	3	6
	L	D	OH	SiL	(80)	(88)	2	6
				L	(16)	(74)	3	5
	L	E	Pt	--	(26)	(38)	4	2
C-3	H	C	CL	SL	---	(131)	1	7
				SiL	---	(131)	1	7

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	C	CL	SiL	---	(152)	1	7
	H	D	OL	SiL	(74)	(106)	3	7
	H	D	OH	L	(140)	(151)	2	7
				C	---	(128)	1	7
	L	B	CH	CL	---	(105)	1	7
				SiCL	---	(124)	1	7
	L	C	SC	SL	---	(158)	1	7
	L	D	ML	SiL	(42)	(80)	2	6
	L	D	OH	SiL	---	(57)	1	3
				L	(28)	(32)	2	2
	L	D	MH	SiL	(107)	(110)	2	7
							78	

Beds of ephemeral lakes (playas) (page 120)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-4	L	A	GP	A	---	300+	1	--
	L	C	Salt	--	---	300+	1	7
	L	C	CL	C	---	(192)	1	7
D-2	L	D	SM	SL	---	300+	1	7
D-4	L	B	CH	C	---	193	1	7
	L	D	ML	CL	---	(32)	1	2
	L	D	MH	L	---	18	1	--
	L	C	CL	L	18	50	2	3
				CL	300+	300+	10	7
	L	D	SM	LS	158	229+	2	7
	L	D	OH	C	---	242	1	7
							22	

Littoral

Beach ridges (page 126)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-2	H	B	CH	SiL	---	(184)	1	7
	H	C	SC	S	---	(156)	1	7
	H	D	SM	SL	---	(212)	1	7
				LS	---	(203)	1	7
	H	D	SP-SM	S	---	300+	1	7
	L	C	SC	SL	---	(64)	1	4
	L	D	SM	SL	---	(57)	1	3
				LS	---	(111)	1	7
	L	D	OH	SiL	---	(81)	1	6
	L	E	Pt	--	---	(43)	1	2

(Continued)

Landscapes in Unconsolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-3	L	D	SM	SL	---	300+	1	7
C-4	H	D	SM	SL	---	300+	2	7
D-2	L	D	SM	SL	---	300+	1	7
							14	

Volcanic

Pyroclastic cones (page 130)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
C-3	H	D	SM	LS	(113)	206+	2	7
	L	D	SM	LS	---	94	1	6
							3	

Landscapes in Consolidated Materials

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC

Sedimentary

Limestone plains (page 135)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	C	CL	SiL	---	124	1	7
	H	D	ML	SiL	158	212	2	7
	L	C	CL	SiL	(125)	(132)	2	7
							5	

Sandstone plains (page 142)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	D	ML	SiL	63	64	2	4
							2	

Limestone-shale plains (page 145)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
D-2	H	B	CH	C	---	(126)	1	7
	H	C	CL	SiL	66	99	2	6
	H	D	ML	SiL	---	64	1	4
	L	C	CL	SiL	(86)	111	2	7
	L	D	OH	L	---	53	1	3
							7	

(Continued)

Landscapes in Consolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
Sandstone-shale plains (page 147)								
D-2	H	C	CL	SiL	---	82	1	6
	L	D	ML	SiL	---	26	1	1
							2	
Sandstone-shale-limestone plains (page 150)								
D-2	H	C	CL	SiL	---	(85)	1	6
	H	D	ML	SiL	148	(152)	2	7
	L	C	CL	SiL	59	(112)	2	7
							5	
Limestone plateaus (page 153)								
D-2	H	C	CL	SiL	74	(122)	5	7
	L	C	CL	SiL	84	(138)	5	7
							10	
Sandstone plateaus (page 156)								
C-3	H	C	CL	SiL	---	(300+)	1	7
	L	D	SM	SL	---	300+	1	7
D-2	H	C	CL	SiL	---	170	1	7
	L	C	CL	SiL	---	123	1	7
							4	
Sandstone-shale plateaus (page 159)								
C-2	H	C	CL	SiL	(116)	(208+)	2	7
C-3	H	C	CL	SiL	---	(152)	1	7
D-2	H	C	CL	SiL	(190)	245+	2	7
	H	D	ML	SiL	---	81	1	6
	L	A	SP	S	---	118	1	--
	L	C	CL	SiL	---	104	1	7
	L	D	ML	SiL	83	(111)	2	7
							10	

(Continued)

Landscapes in Consolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
Limestone hills or mountains (page 162)								
D-2	H	B	CH	C	---	300+	1	7
	H	C	CL	SiL	---	300+	1	7
	L	C	CL	SiL	212	256+	2	7
							4	
Dolomite hills or mountains (page 165)								
D-2	H	C	CL	SiL	148	(149)	2	7
	L	C	CL	SiL	72	(100)	2	7
							4	
Shale hills or mountains (page 167)								
D-2	H	C	CL	L	---	(82)	1	6
	H	D	ML	SiL	---	(58)	1	3
	H	D	SM	SL	---	300+	1	7
	L	D	SM-SC	SL	---	197	1	7
	L	C	CL	SiL	(69)	(72)	2	5
							6	
Sandstone-shale hills or mountains (page 170)								
D-2	H	D	SM	SL	---	(146)	1	7
	H	D	SM-SC	SL	---	175	1	7
	L	C	CL	SiL	---	61	1	4
	L	D	ML	SiL	---	107	1	7
							4	
Limestone-shale hills or mountains (page 173)								
D-2	H	C	CL	SiL	---	197	1	7
	H	D	SM	SL	---	118	1	7
	H	D	CL-ML	SL	---	300+	1	7
	L	C	CL	SiL	---	192	1	7
	L	D	CL-ML	SL	---	(111)	1	7
							5	

(Continued)

Landscapes in Consolidated Materials (Continued)

Climate	Site	STC	USCS	USDA	RCI (Min)	RCI (Mean)	N	VC
				Igneous				
Basalt plains and plateaus (page 176)								
C-3	L	C	CL	SiL	---	(152)	1	7
C-4	L	C	CL	SiL	---	300+	1	7
D-3	L	D	OL	SiL	---	(73)	1	5
							3	
Granite hills or mountains (page 180)								
D-2	H	D	SM	SL	---	(300+)	1	7
	L	D	SM	SL	---	155	1	7
							2	
				Metamorphic				
Slate hills or mountains (page 183)								
D-2	H	C	CL	SiL	---	20	1	1
	L	D	ML	SiL	---	130	1	7
							2	
Gneiss hills or mountains (page 185)								
D-2	H	B	CH	C	---	300+	1	7
	L	C	CL	SiL	---	83	1	6
							2	
Schist hills or mountains (page 187)								
D-2	H	D	SM	SL	---	(134)	1	7
	L	C	CL	SiL	---	300+	1	7
							2	

APPENDIX C: GENERALIZED LANDSCAPE-PARENT MATERIAL MAPS

1. The generalized landscape-parent material maps which comprise Appendix C have been prepared to assist in the evaluation of trafficability from airphotos. Evaluation procedures are facilitated by a prior knowledge of the landscapes or process and structure that one will find in a region.

2. There are nine landscape-parent material maps, showing worldwide geographic occurrence in each case. Similar landscapes may be on the same figure as in the case of fig. C4, coastal plains, lacustrine plains, and playa plains. The scale of the maps precludes precise landscape boundaries and limits the occurrences to those of sufficient size to be drawn without an excessive exaggeration in areal coverage. The maps are intended only as generalized guides to assist in interpretation.

3. In places overlapping of landscape-parent material areas occurs because many units are intimately associated with one another. In such instances, it is of assistance for the interpreter to be aware of the complex nature of the area. An example may be found by comparing figs. C1, C2, and C3, sand dunes, loess plains, and glacial moraines, respectively. Wind action in glaciated areas often results in the development of wind-blown deposits, and the development of soils in such areas is dependent upon all three landscape types. In some areas it is impossible to differentiate between rock types at the scale of the maps, and in such instances there will also be some duplication of coverage. For example, compare the metamorphic shields and granitic shields in figs. C7 and C8. From such repetition of coverage in an area the interpreter may expect either rock type and may indeed find it difficult to impossible to subdivide the materials even with the aid of photographs.

4. The following sources were used in the compilation of the maps:

Balzak, S. S., Vazyutin, V. F., and Feigin, Y. G., Economic Geography of the U.S.S.R., C. D. Harris, ed. The Macmillan Company, New York, N. Y., 1949.

Charlesworth, J. K., The Quaternary Era. Edward Arnold and Company, Ltd., London, 1957. In two volumes.

Cleland, H. R., Geology - Physical and Historical. American Book Company, New York, N. Y., 1916.

Coleman, A. P., Ice Ages, Recent and Ancient. The Macmillan Company, New York, N. Y., 1929.

Department of the Army, Geology and Its Military Application. Technical Manual 5-545, August 1952.

Eardley, A. J., Structural Geology of North America. Harper and Brothers, New York, N. Y., 1951.

Fenneman, N. M., Physiography of Western United States. McGraw-Hill Book Company, Inc., New York, N. Y., 1931.

_________, Physiography of Eastern United States. McGraw-Hill Book Company, Inc., New York, N. Y., 1938.

Flint, R. F., Glacial and Pleistocene Geology. John Wiley and Sons, Inc., New York, N. Y., 1957.

Gamow, G., Biography of the Earth; Its Past, Present and Future. Viking Press, Inc., New York, N. Y., 1941.

Gignoux, M., Stratigraphic Geology, translated by G. G. Woodford. W. H. Freeman and Company, San Francisco, Calif., 1955.

Hobbs, W. H., Earth Features and Their Meaning. The Macmillan Company, New York, N. Y., 1935.

Jenks, W. F., ed., Handbook of South American Geology; An Explanation of the Geologic Map of South America. Geological Society of America Memoir 65, 1956.

Lobeck, A. K., Physiographic Diagram of Europe. Geographical Press, 1923.

_________, Geomorphology; An Introduction to the Study of Landscapes. McGraw-Hill Book Company, Inc., 1939.

_________, Physiographic Diagram of Asia. Geographical Press, 1945.

_________, Physiographic Diagram of Africa. Geographical Press, 1946.

_________, Physiographic Diagram of North America. Geographical Press, 1950.

Marr, J. E., Deposition of the Sedimentary Rocks. Cambridge University Press, Cambridge, England, 1929.

Moore, R. C., Introduction to Historical Geology, 2d ed. McGraw-Hill Book Company, Inc., New York, N. Y., 1958.

Schuchert, Charles, and Dunbar, Carl O., Outlines of Historical Geology, 4th ed. John Wiley and Sons, Inc., New York, N. Y., 1941.

Smith, G. H., Physiographic Diagram of South America. Geographical Press, 1935.

Thornbury, W. D., Principles of Geomorphology. John Wiley and Sons, Inc., New York, N. Y., 1954.

Twenhofel, W. H., Principles of Sedimentation, 2d ed. McGraw-Hill Book Company, Inc., New York, N. Y., 1950.

Wadia, D. N., Geology of India, 3d ed. The Macmillan Company, New York, N. Y., 1953.

Weeks, L. G., "Highlights on developments in foreign petroleum fields."

American Association of Petroleum Geologists Bulletin, vol 31, No. 7 (July 1947), pp 1135-1193.

Weeks, L. G., "Geologic architecture of Circum-Pacific." _American Association of Petroleum Geologists Bulletin,_ vol 43, No. 2 (February 1959), pp 350-380.

Wright, W. B., _The Quaternary Ice Age._ The Macmillan Company, New York, N. Y., 1937.

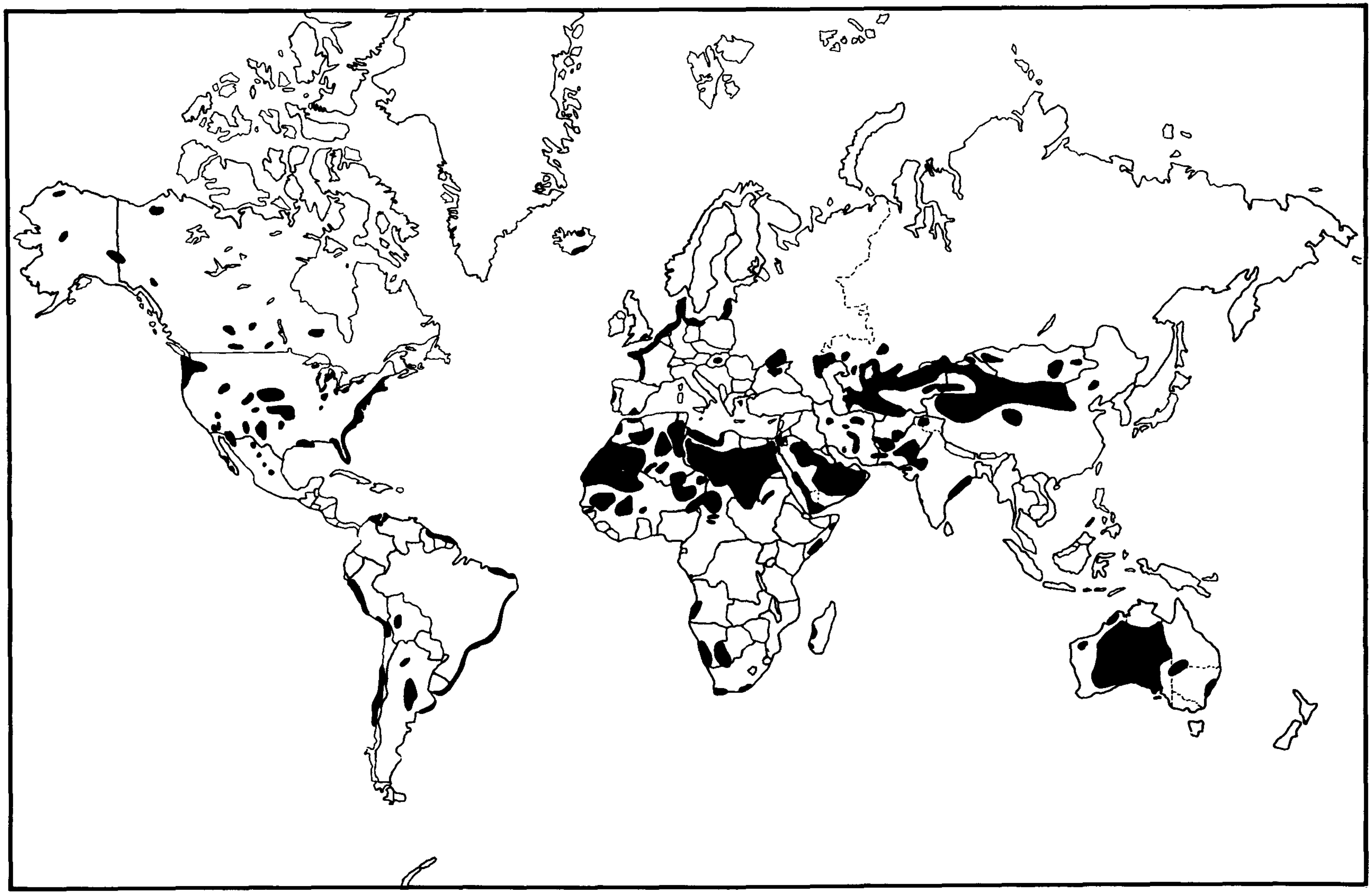


Fig. C1. Sand dunes

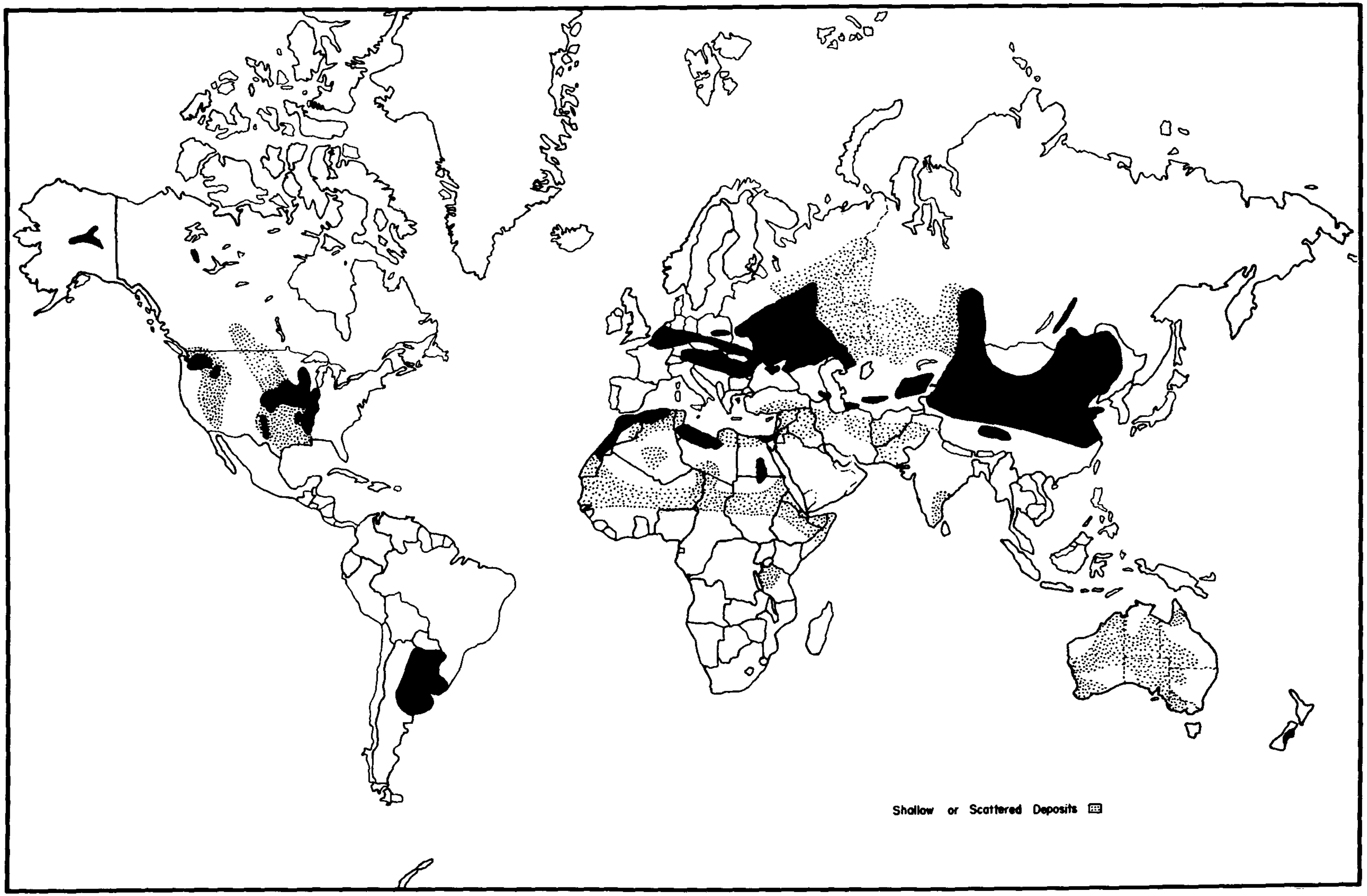


Fig. C2. Loess plains

Fig. C3. Glacial ground moraines, ridge moraines, kames, outwash plains, drumlins, and eskers

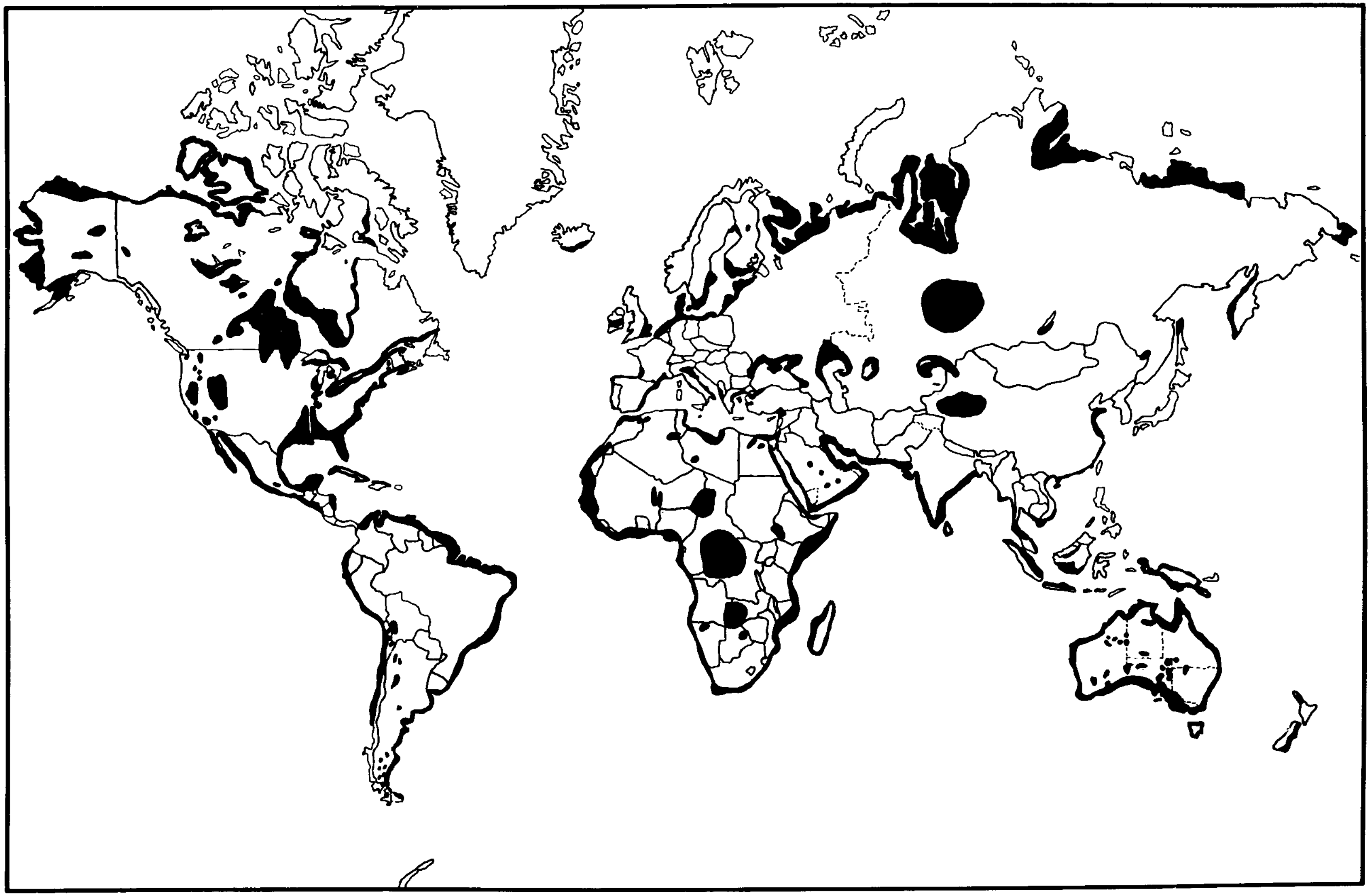


Fig. C4. Coastal plains, lacustrine plains, and playa plains

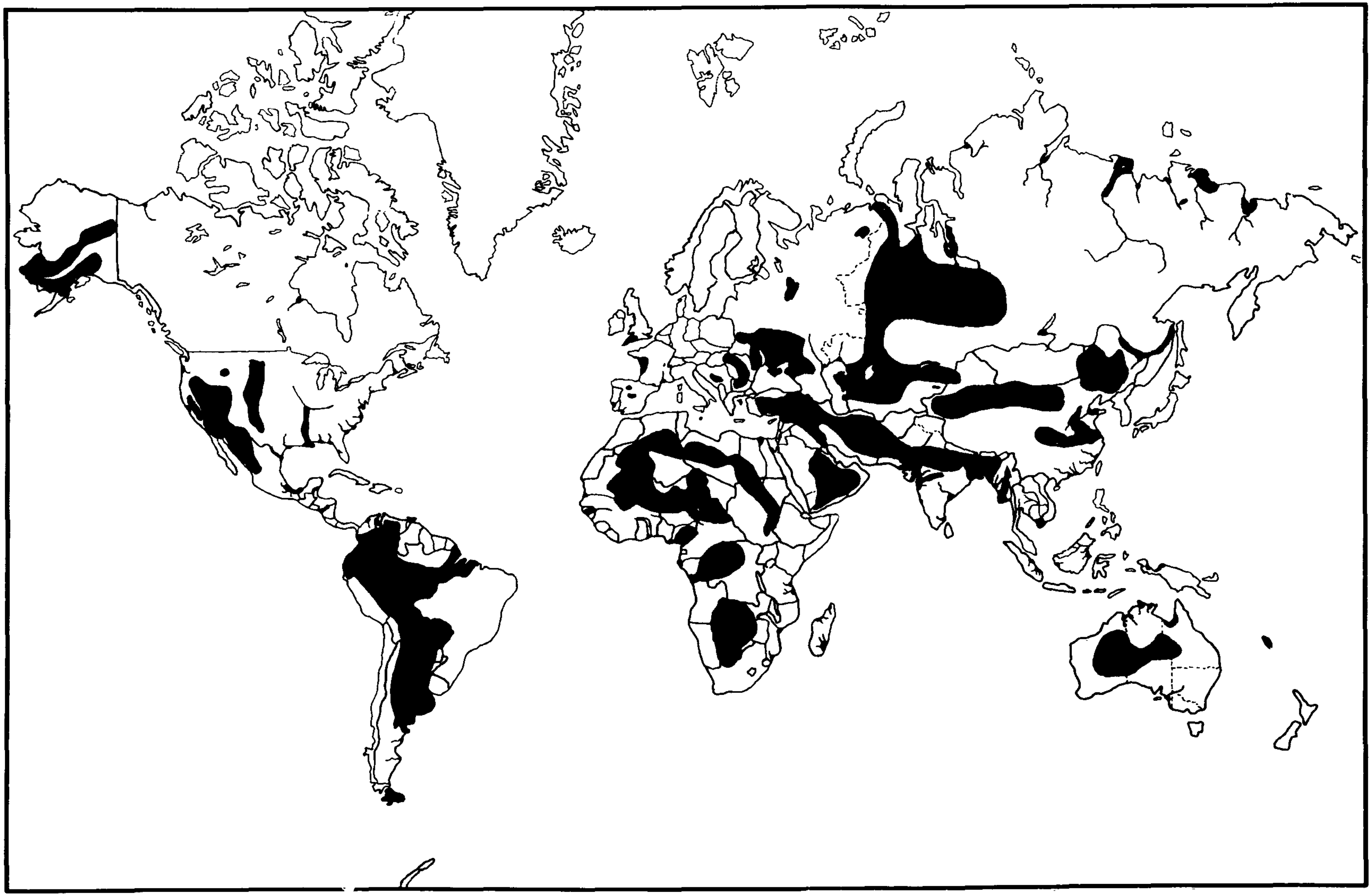


Fig. C5. Alluvial aprons, alluvial fans, floodplains, terraces, deltaic surfaces, and arroyos

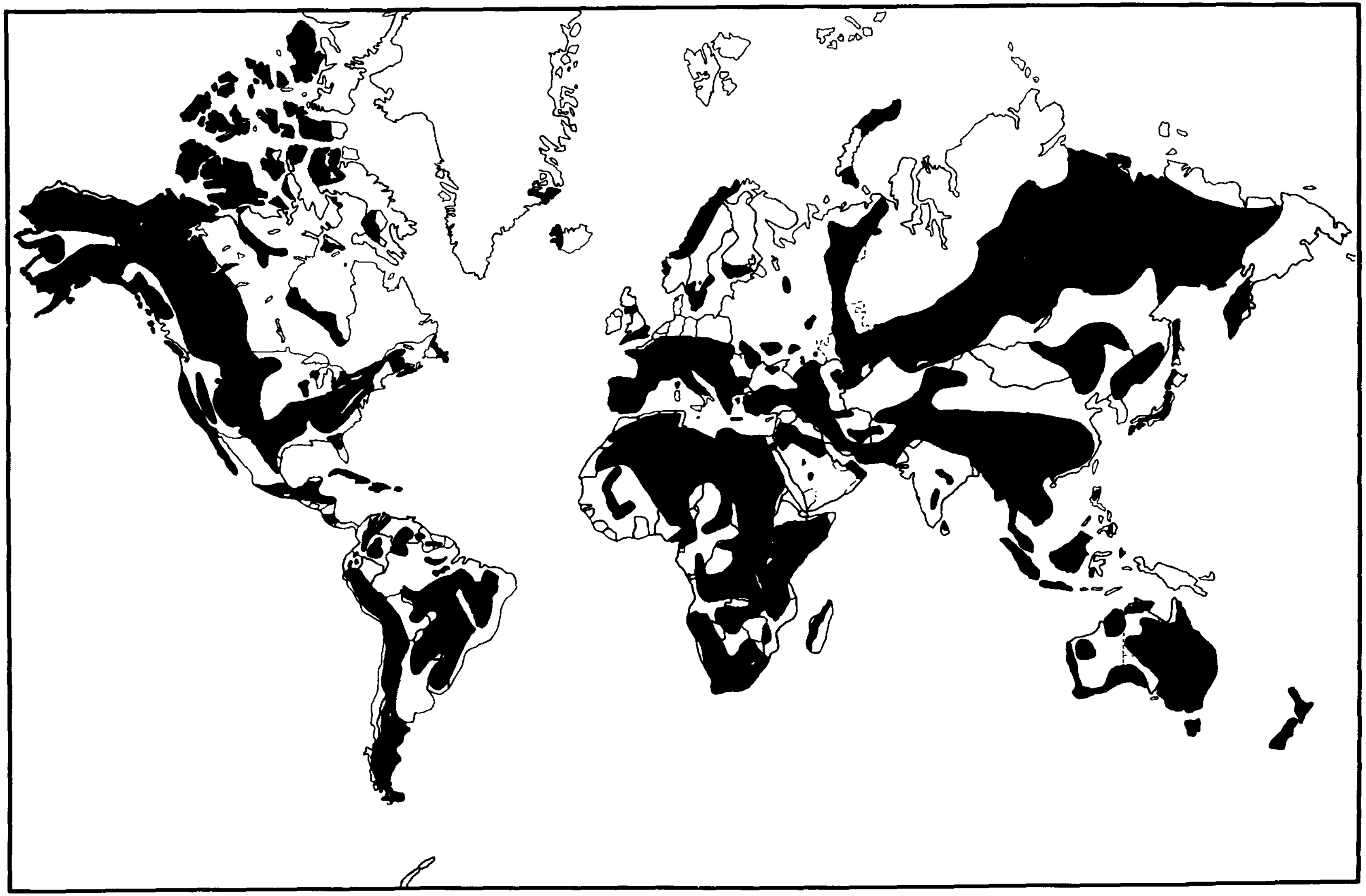


Fig. C6. Sedimentary anticlines and synclines, sedimentary plateaus, and sedimentary plains

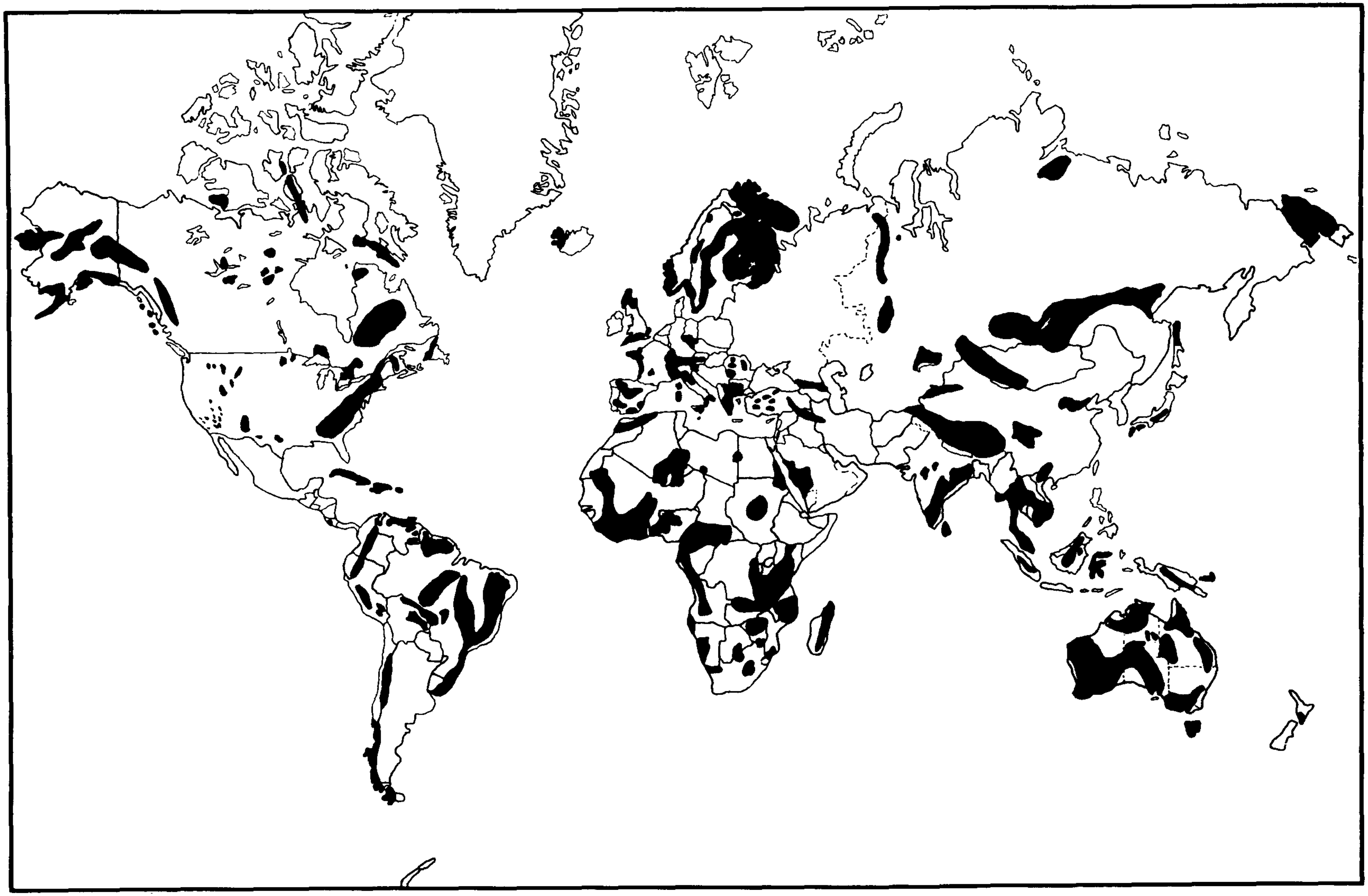


Fig. C7. Metamorphic hills

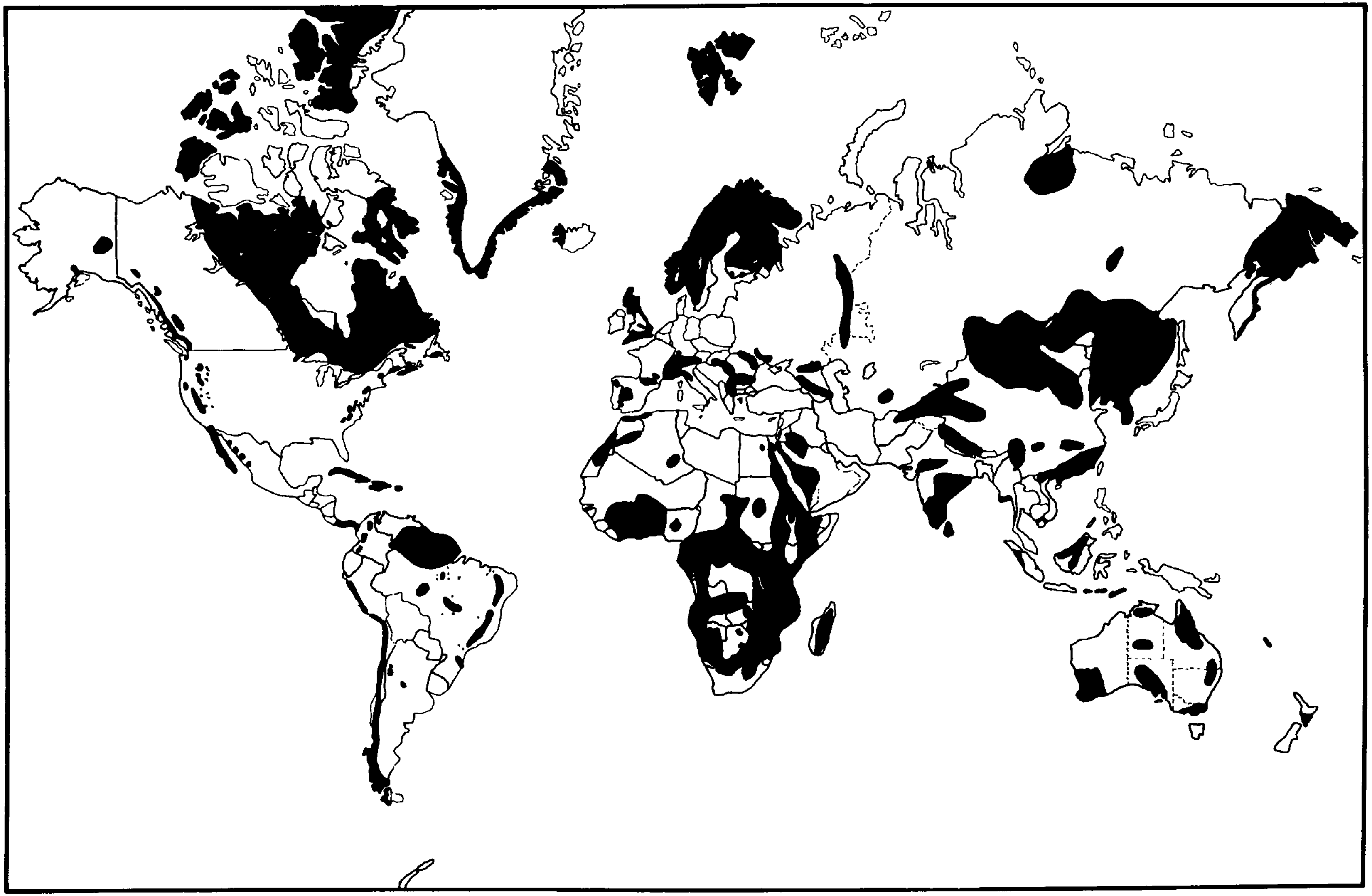


Fig. C8. Granitic shields and granitic mountains

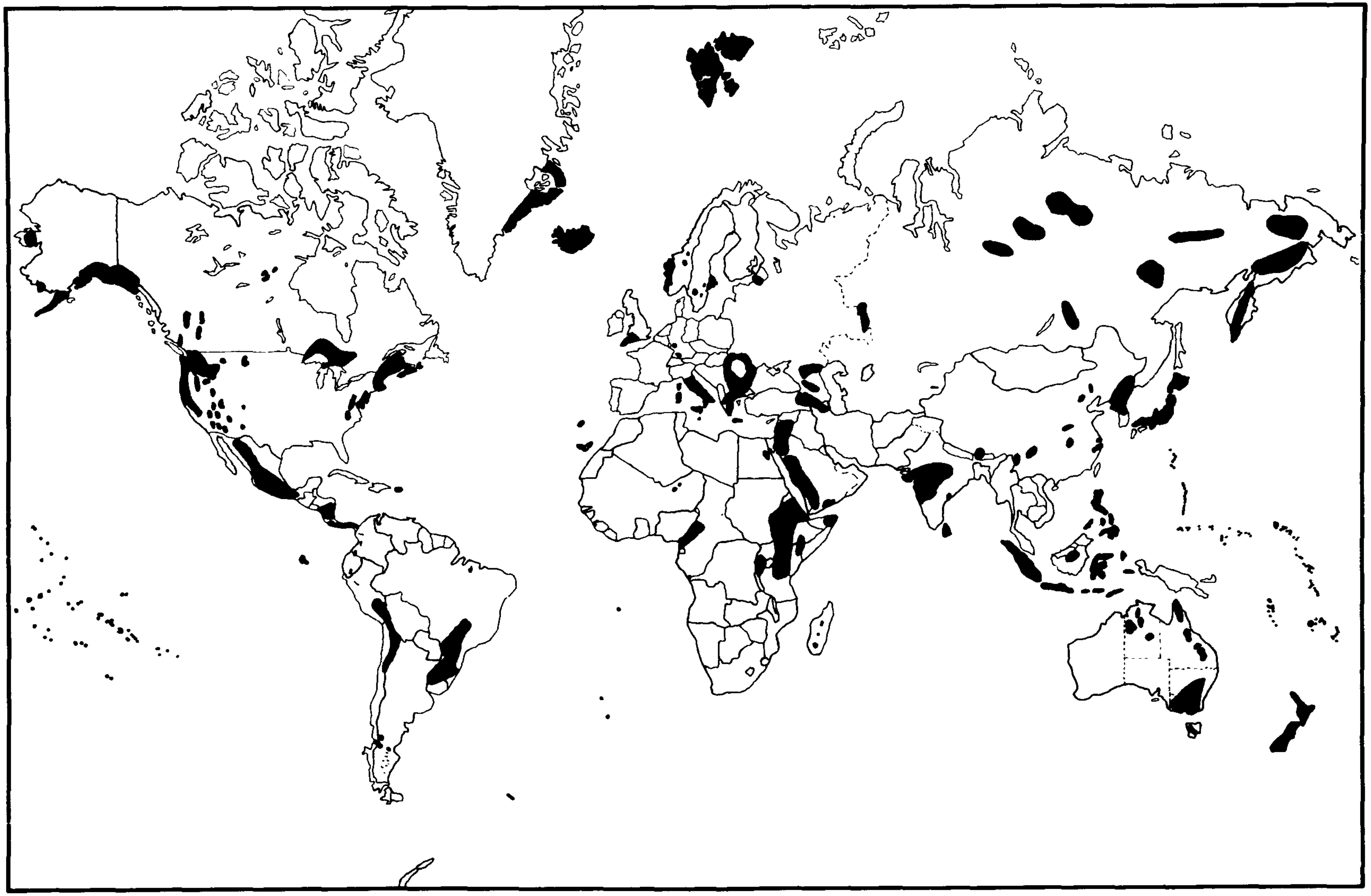


Fig. C9. Lava plateaus, lava coulees, lava cones, cinder cones, and volcanic mountains

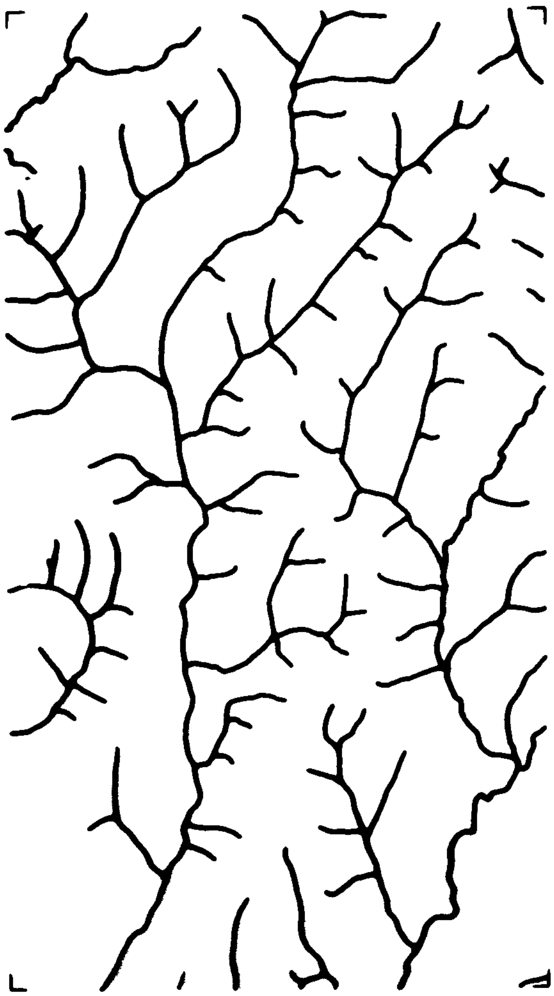


Fig. 40

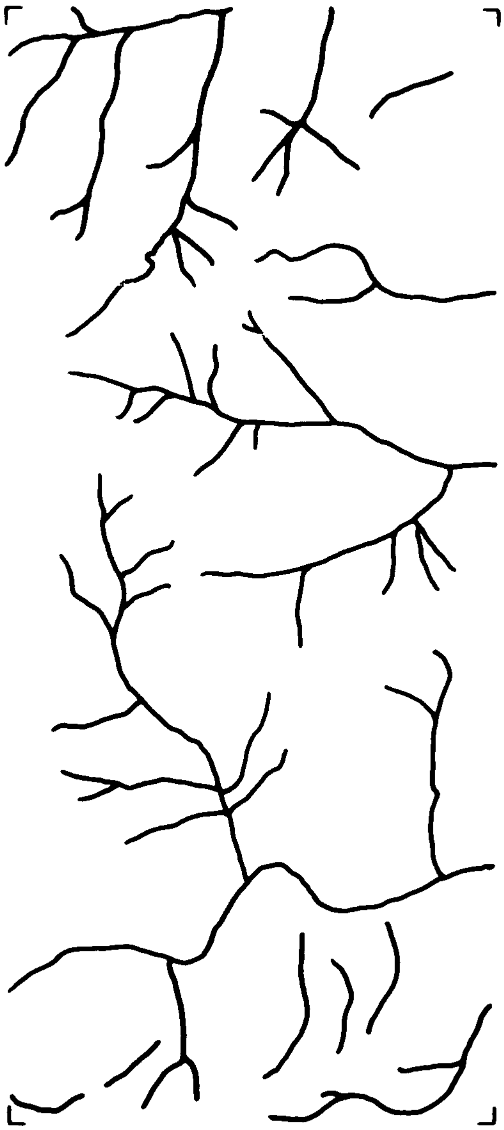


Fig. 42

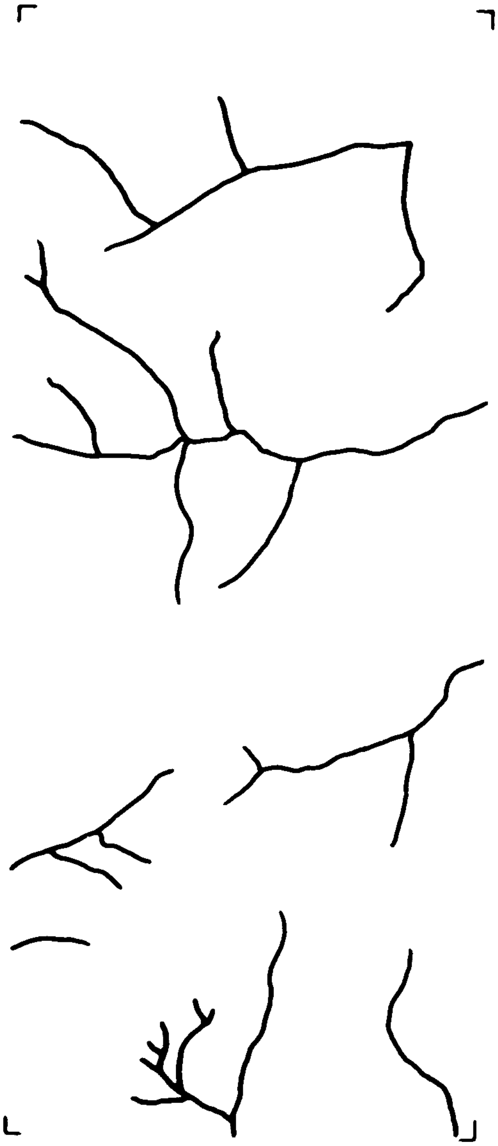


Fig. 44

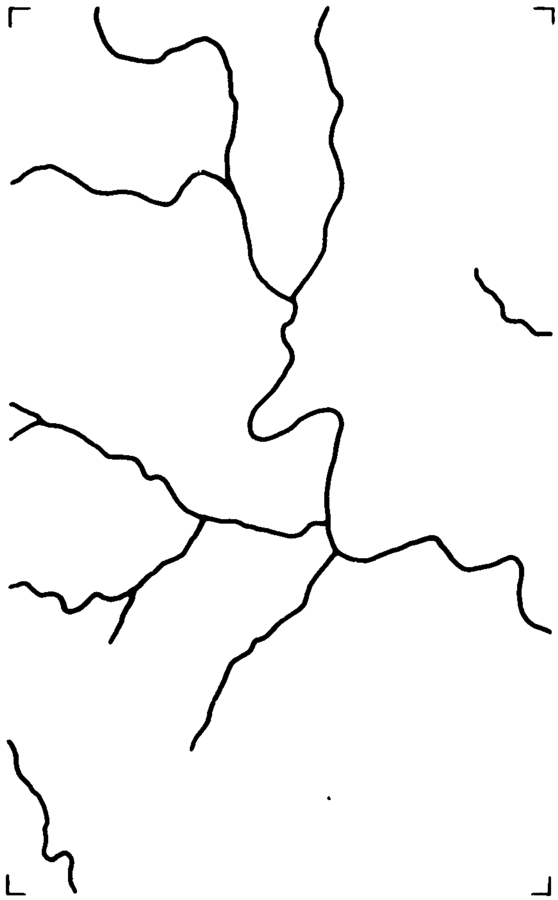


Fig. 45

Fig. 47

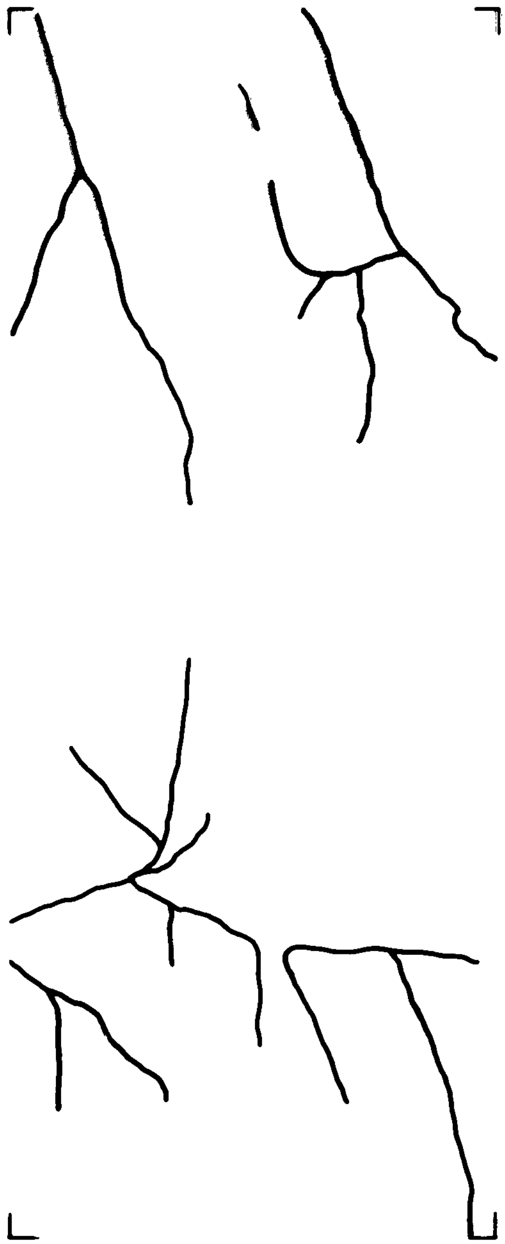


Fig. 48

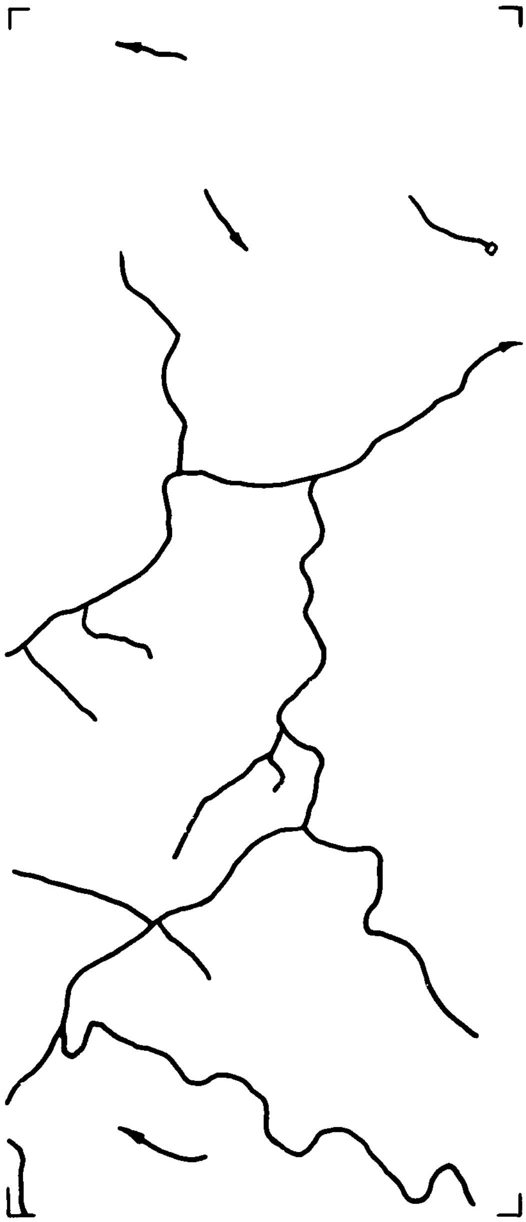


Fig. 50

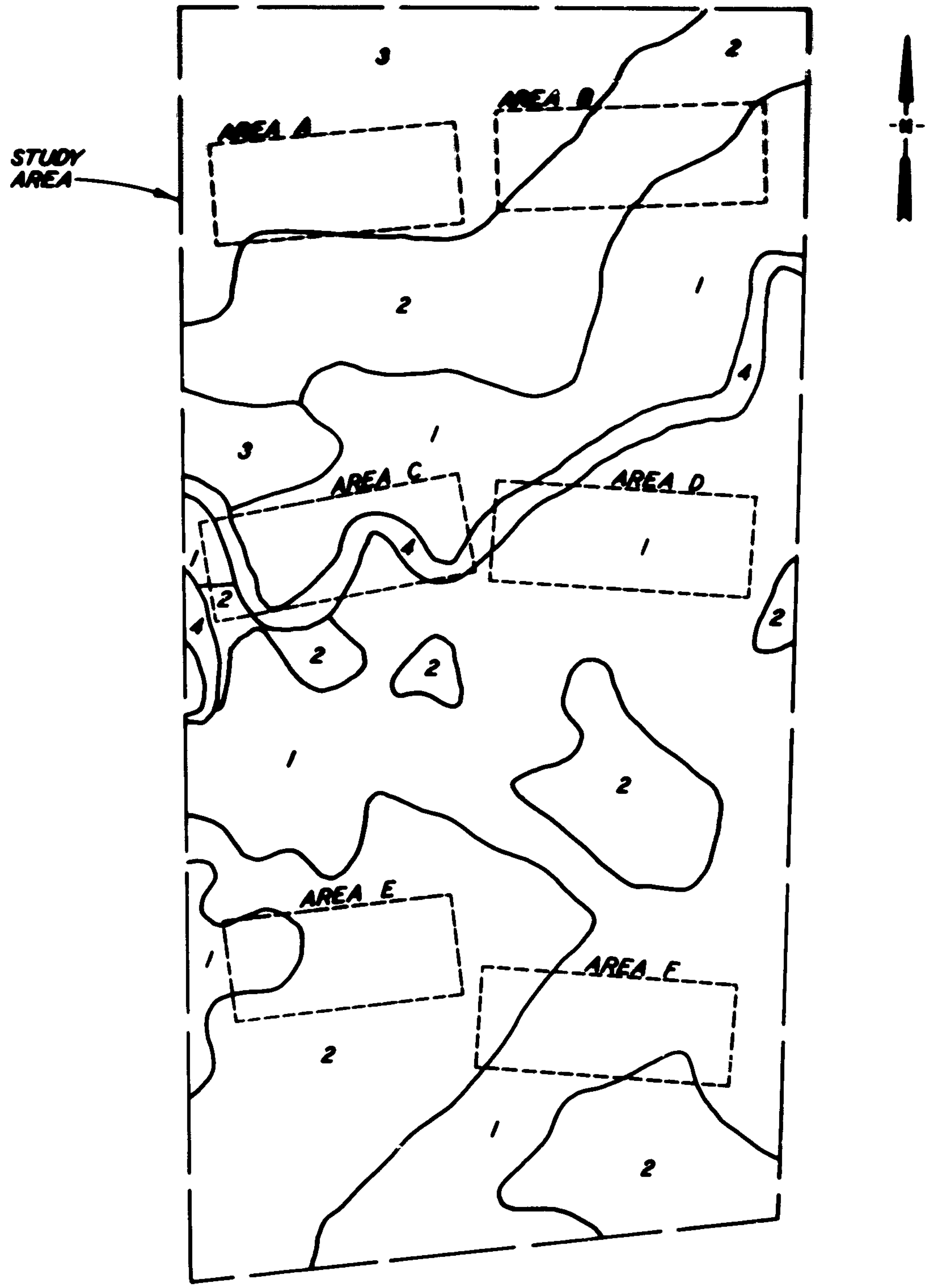


Fig. 56. Overlay of study area, Hart County, Kentucky (climate D-2)

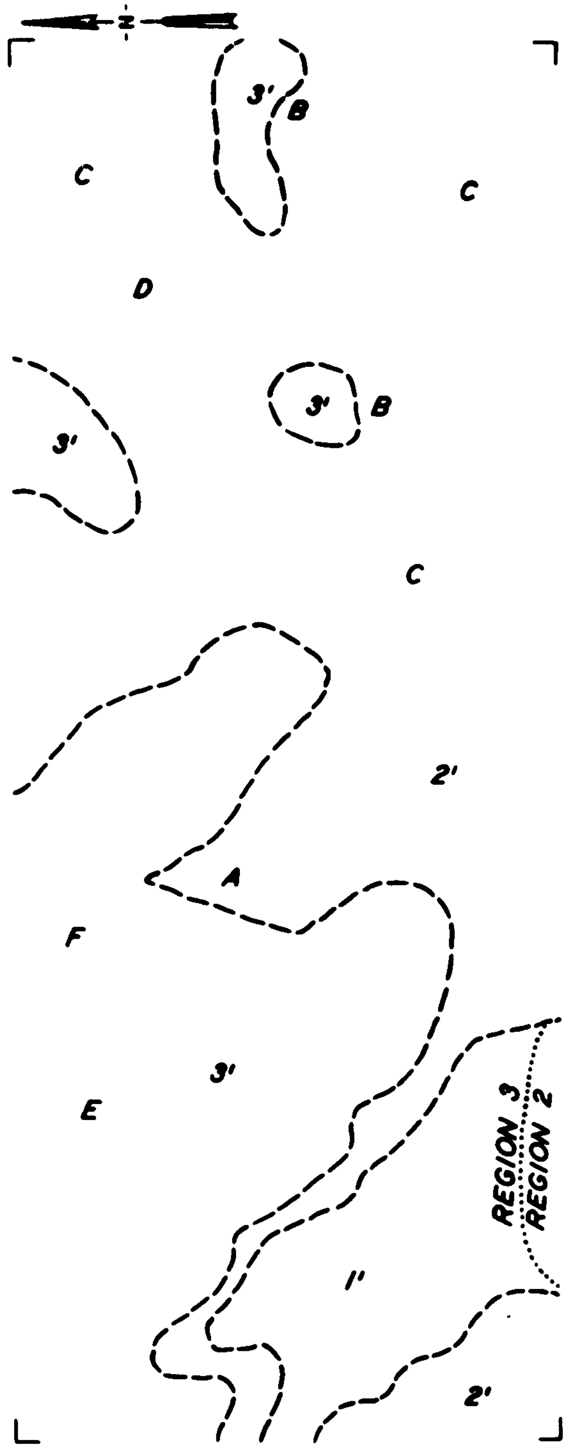


Fig. 58. Area A, Hart County, Kentucky

Fig. 60. Area B, Hart County,
Kentucky

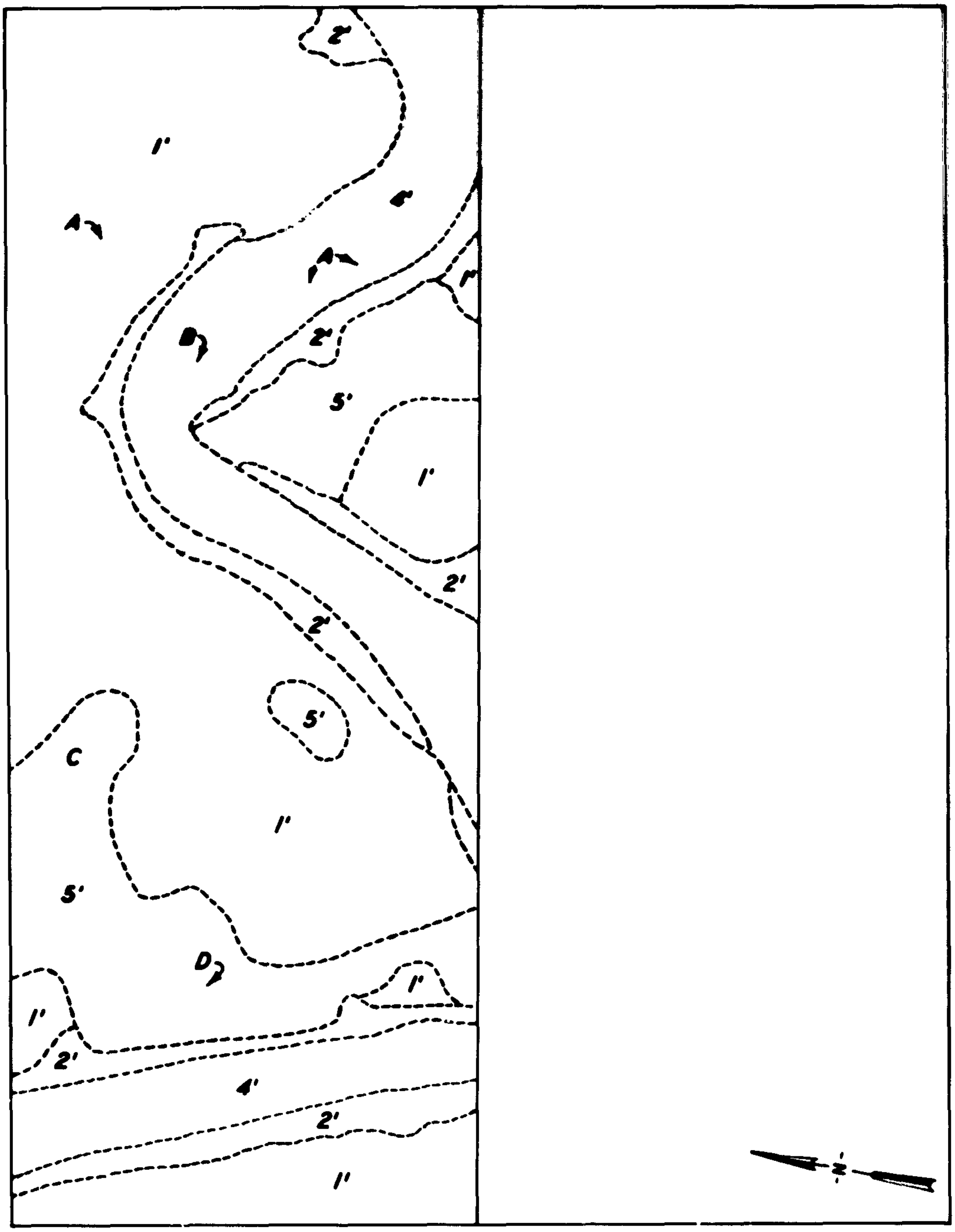


Fig. 62. Area C, Hart County, Kentucky

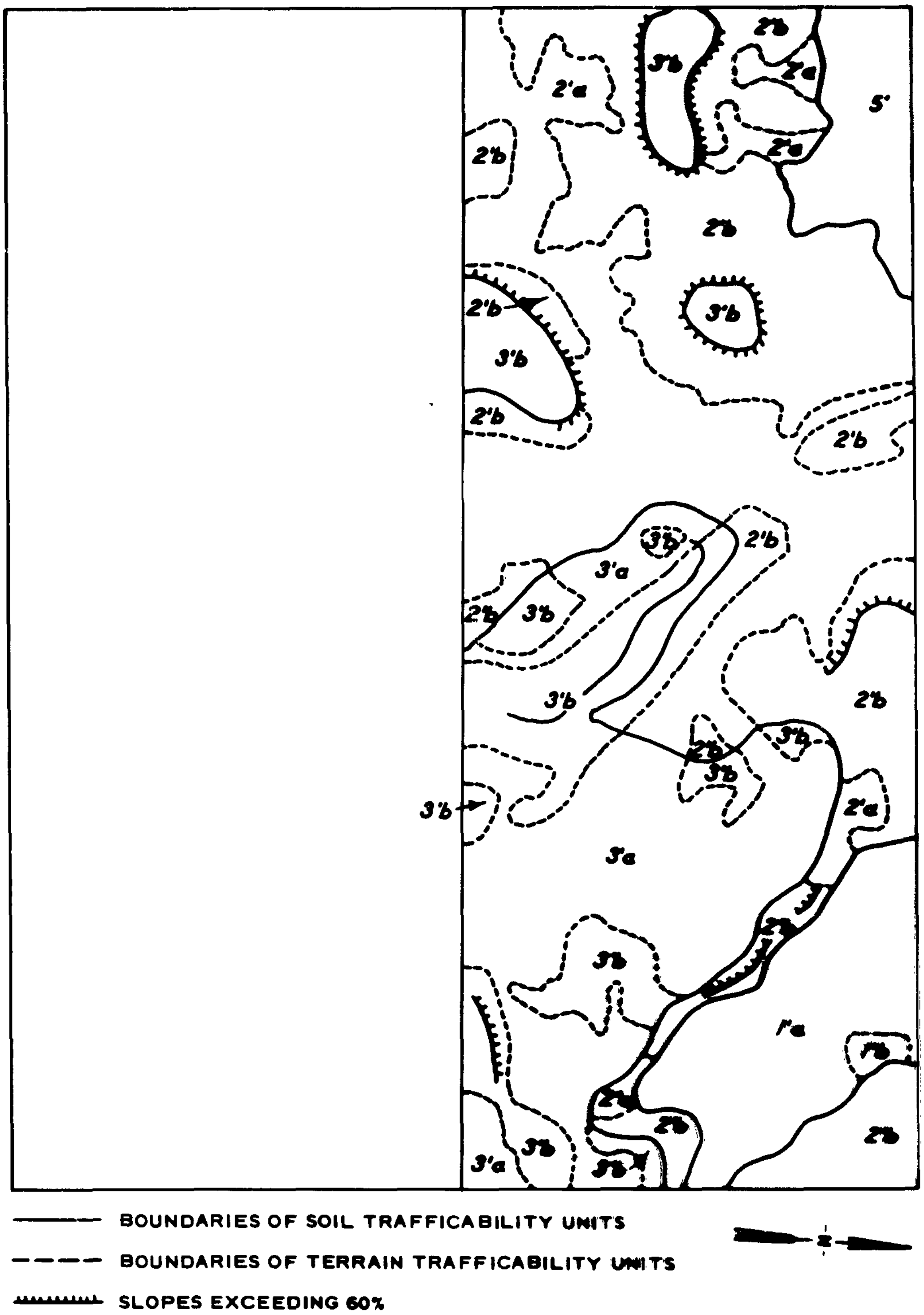


Fig. 64. Area A, Hart County, Kentucky

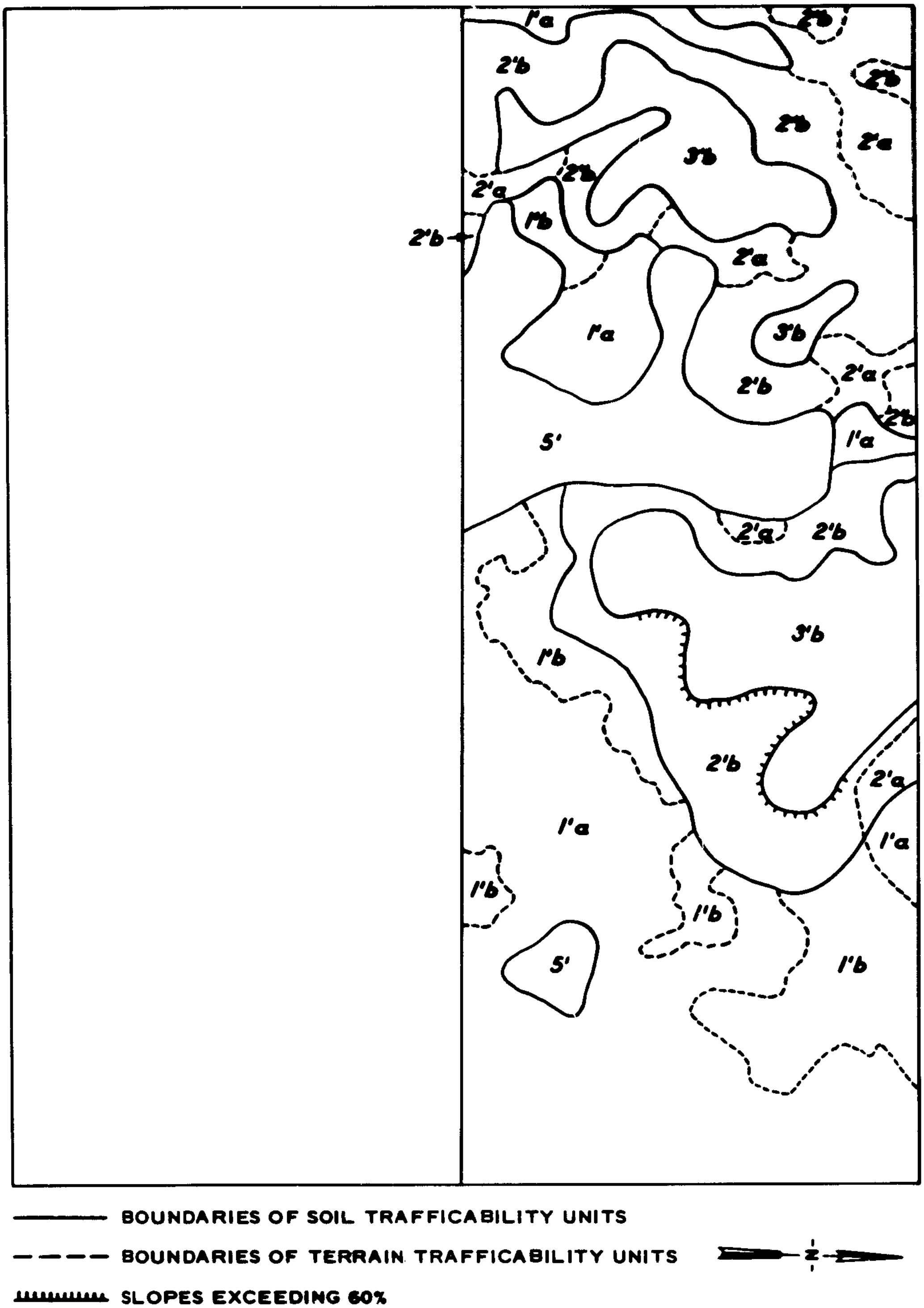


Fig. 65. Area B, Hart County, Kentucky

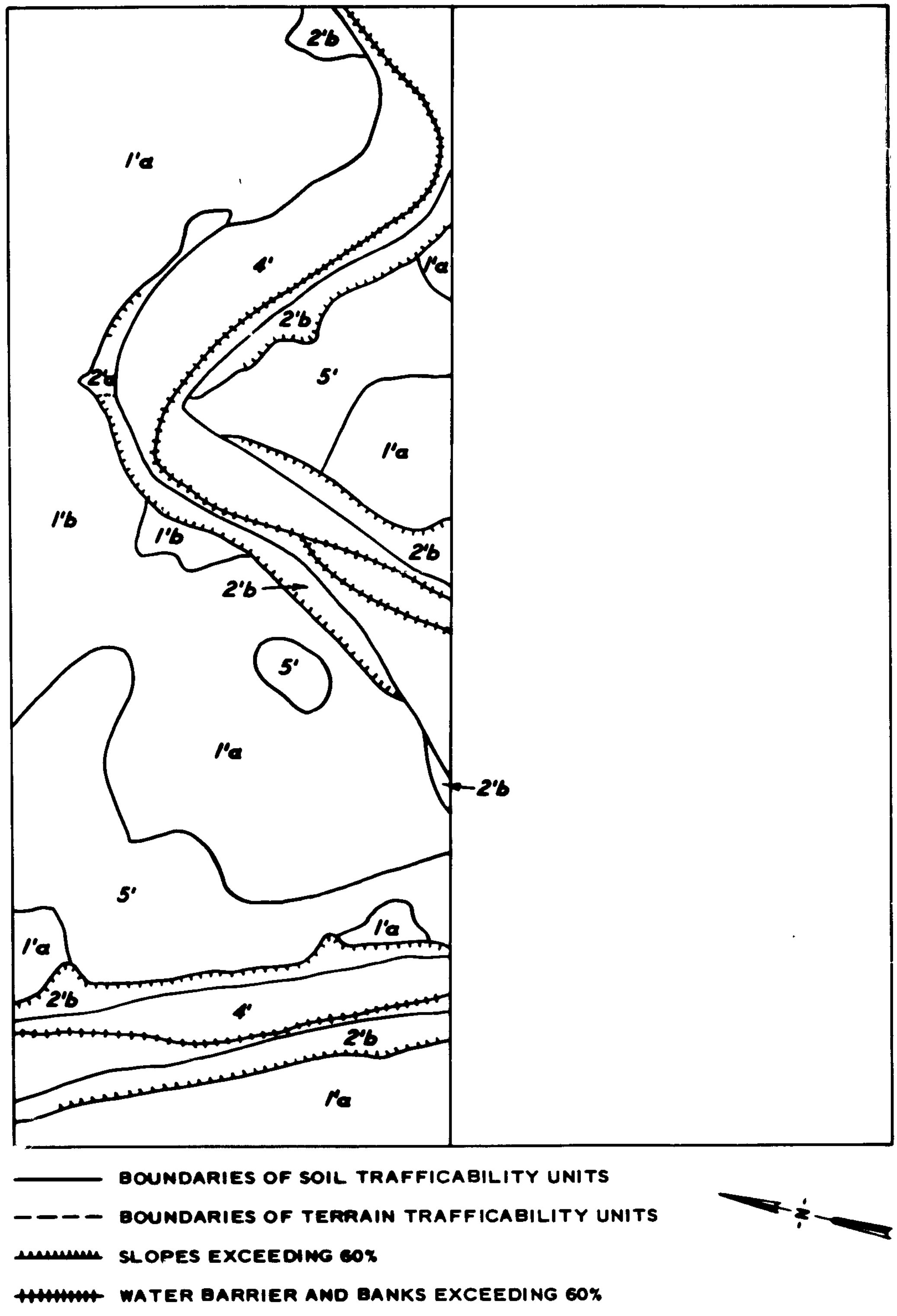
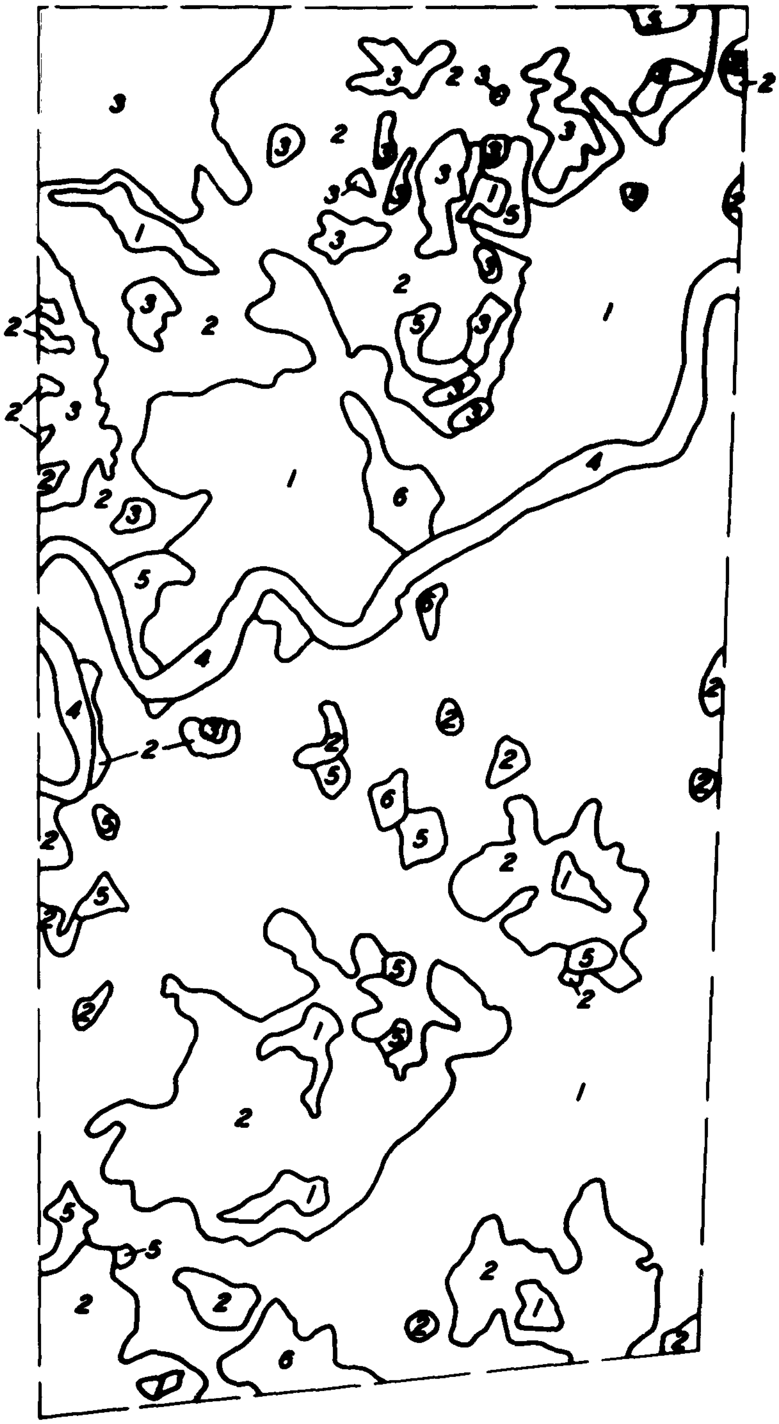


Fig. 66. Area C, Hart County, Kentucky



Approximate scale, 1:95,000

For meaning of symbols, see table 12

Fig. 67. Terrain trafficability map, Hart County, Kentucky